APPENDIX 6-B

Previous Investigations Summary Information

CURRENT CONDITIONS /RELEASE ASSESSMENT

EAST HELENA FACILITY

Prepared for:

ASARCO Incorporated
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
2727 Airport Road
Helena, MT 59601

September 1998

Revised January 1999

3. EXISTING DATA SUMMARY

This section describes the types of data which are available, areas of the Plant to which the data apply, the purpose for which the data were collected, quality assurance/quality control standards under which the data were collected, and whether the gathering and analysis of these data met applicable quality assurance and quality control and other applicable gathering and analysis procedures.

3.1 DATA SOURCES

The data sources inventory in Appendix 3-1-1 lists the sources of existing data and includes related documents which might be used to define, in whole or in part, the nature and extent of any hazardous waste or hazardous constituent releases, if any, at, or migrating from, the Plant. This Appendix also describes the available data, publication dates, data location, level of data validation (see Section 3.3 for data validation level descriptions), document retention time and confidentiality status. For completeness, the data sources inventory also contains a listing of all available reports and documents relating to the collection and interpretation of the data such as work plans, quality assurance plans, sampling plans, validation reports, construction reports, construction documents (plans and specifications), project reports and EPA responses. A complete database of water sample results is in Appendix 3-1-2. Soil sample results are in Appendix 3-1-3. Exhibit 3-2-1 shows the location of historical monitoring sites within the study area.

3.2 DATA DESCRIPTION

Because large portions of the data were collected in specific regard to work plans and sampling plans (which often included more than one operable unit or subunit), the discussion in this section is necessarily work plan/sampling plan specific instead of operable unit or subunit specific. For example, the Phase I Hydrogeologic Investigation of the Asarco East Helena Facility Water Resources Monitoring Plan (Asarco and Hydrometrics, 1984) resulted in the sampling of groundwater (an operable unit), Lower Lake (a component of the Process

Ponds Subunit), Surface Water (part of the Surface Water/Surface Soils Operable Unit) and subsurface soils. Specific segments of a specific study, for example, Lower Lake sampling in the Phase I hydrogeologic study, can be referenced to a specified subunit by referring to Figure 1-1-2. The discussion in this section is also chronological.

The following are the major categories of data addressed in subsequent sub-sections.

- RI/FS and Post RI/FS Biannual (twice yearly) Sampling Data (Section 3.2.1)
- Post RI/FS Plant Site Soils and Ore Storage Area Data (Section 3.2.2)
- Post RI/FS Process Fluid Circuit Data (Section 3.2.3)
- Post RI/FS Surface Water and Associated Soils Data (Section 3.2.4)
- Post RI/FS Groundwater Well Construction Data (Section 3.2.5)
- General Storm Water Discharge Data (Section 3.2.6)

3.2.1 RI/FS Data and Post RI/FS Biannual Sampling Data

The RI/FS and Post RI/FS Biannual Sampling data were collected and analyzed according to the following plans:

1. Phase I (1984 through 1985) - Hydrogeological Investigation of the Asarco East Helena Facility Water Resources Monitoring Plan (Asarco and Hydrometrics, 1984). This phase consisted of sampling of the following:

    - Soils samples collected during the drilling of monitoring wells
    - Plant process fluids (Lower Lake)
    - Surface Water (Prickly Pear Creek, Wilson Ditch and Upper Lake)
    - Groundwater (Plant site and private wells)

2. Phase II (fall 1986-spring of 1987) - Water Resources Investigation, Asarco East Helena Plant, Phase II Remedial Investigation Work Plan (Hydrometrics, 1986). Phase II expanded on the Phase I work plan by adding the following:

- Sampling of East Helena municipal wells
- Synoptic run sampling of Prickly Pear Creek
- Investigation of precipitation water movement through the slag pile
- Determination of arsenic (III) and arsenic (V) concentrations in groundwater and surface water
- Determination of iron (II) and iron (III) concentrations in groundwater and surface water

3. Comprehensive Remedial Investigation/Feasibility Study Plan (Hydrometrics, 1987); Comprehensive RI/FS (fall 1987 through fall 1989). For the Comprehensive RI/FS, the Phase II sampling plan was expanded to include:

    - Air sampling (not addressed in this report)
    - Ore storage area sampling
    - Organic contamination evaluation of plant surface soils and certain plant site and municipal wells
    - East Helena soil core drill holes
    - Wilson Ditch sediment core sampling
    - Process ponds sediment sampling
    - Storm water runoff sampling

4. The Post Comprehensive RI/FS biannual sampling (spring 1989 to present) continued the monitoring of the following:

    - Plant site wells
    - East Helena municipal wells
    - Designated private wells
    - Plant Process Fluids
    - Prickly Pear Creek

Table 3-2-1 is a historical summary of the water, soil and slag samples collected during major facility investigations. Table 3-2-2 is a listing of the corresponding parameter schedules.

These schedules are general lists of parameters that were analyzed for each site; however, some sampling events may exclude parameters that are listed or include non-listed parameters. The quality of these data is discussed in Section 3.3.

3.2.2 Post RI/FS Plant Site Soils and Ore Storage Area Data

Post RI/FS collection of soils data was conducted primarily in association with construction activities or source area remediation. Data collection associated with these remedial activities is described in Section 3.2.3. Any additional post RI/FS site characterization sampling of surface soils, stockpiles, slag and subsurface soils is described below.

~~Plant Site surface soils and ores storage areas include the following data:~~

- ~~Surface Soils~~
- ~~Stockpiles~~
- ~~Slag~~

3.2.2.1 Surface Soils (1990 to Present)

Post RI/FS soils data were collected in the Acid Plant Sediment Drying Area and in the area between Upper and Lower Lakes as part of continued investigations in these areas. Surface and subsurface soil sampling was conducted at test pit, soil boring and monitoring well locations. These soils data are described with subsurface soils in Section 3.2.2.2.

[Note: Following discussion of soils data moved to subsurface soils section.]

~~In November of 1990, soil samples were taken at eight test pit sites (LLB-1 through LLB-8) in the area between Upper and Lower Lake in order to characterize the soils. Each site was sampled at the following intervals: 0-1 ft., 2-3 ft., 3-5 ft., and 9-10 ft. Samples were analyzed for Toxic Characteristic Leaching Procedure (TCLP) and total arsenic metals. These data~~

TABLE 3-2-1. HISTORICAL SUMMARY OF THE WATER, SOIL AND SLAG SAMPLING PROGRAM

		Phase I			Phase II			Comp RI/FS			Post RI Monitoring		
		1984 to 1985			Fall 1986 - Spring/Summer 1987			Fall 1987 to Fall/Winter 1988			Spring 1989 to Fall/Winter 1997		
Site Code	Site Description	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]
Plant Site Monitoring Wells													
APSD-1	Shallow - Plant Site										SA 1991-97; P 1994-96	29	F
APSD-2	Shallow - Plant Site										SA 1991-97; P 1994-96	29	F
APSD-3	Shallow - Plant Site										SA 1991-97; P 1994-96	29	F
APSD-4	Shallow - Plant Site										SA 1991-97; P 1994-96	29	F
APSD-7	Shallow - Plant Site										SA 1993-97 ; P 1994-96	52	F
APSD-8	Shallow - Plant Site										SA 1993-97 ; P 1994-96	55	F
APSD-9	Shallow - Plant Site										SA 1993-97 ; P 1994-96	24	F
APSD-10	Shallow - Plant Site										SA 1993-97 ; P 1994-96	24	F
APSD-11	Shallow - Plant Site										SA 1993-97 ; P 1994-96	24	F
APSD-12	Shallow - Plant Site										SA 1993-97 ; P 1994-96	24	F
APSD-13	Shallow - Plant Site										SA 1993-97 ; P 1994-96	24	F
APSD-14	Shallow - Plant Site										SA 1993-94; P 1994	5	F
DH-1	Shallow - Upgradient	S 1985	4	A, B & C	SA	2	D & E	SA	3	E	SA	18	F
DH-2	Shallow - Upgradient	S 1985	4	A, B & C	SA	2	D & E	SA	3	E	SA	18	F
DH-3	Shallow - Upgradient	S 1985	4	A, B & C	SA	2	D & E	SA	3	E	SA	19	F
DH-4	Shallow - Upgradient	S 1985	4	A & C	SA	2	D & E	SA	3	E	SA 1989-97; P 1994-96	55	F
DH-5	Shallow - Plant Site	S 1985	4	B & C	SA	2	D & E	SA	3	E	SA 1989-97; P 1994-96	43	F
DH-6	Shallow - Plant Site	S 1985	4	A, B & C	SA	2	D & E	SA	3	E	SA	18	F
DH-7	Shallow - Plant Site	S 1985	4	A, B & C	SA	2	D & E	SA	3	E	SA	18	F
DH-8	Shallow - Plant Site	S 1985	4	A, B & C	SA	2	D & E	SA	3	E	SA	18	F
DH-9	Shallow - Plant Site	S 1985	4	B & C	SA	2	D & E	SA	2	E	SA	12	F
DH-10	Shallow - Plant Site	S 1985	4	A, B & C	SA	2	D & E	SA	3	E	SA	14	F
DH-10A	Shallow - Plant Site										11/95	1	F
DH-11	Shallow - Plant Site	S 1985	5	A, B & C	SA	2	D & E	SA	3	E	SA	18	F
DH-12	Shallow - Plant Site				S	4	E	11/87	2	E	SA	13	F
DH-13	Shallow - Plant Site				S	4	E	SA	3	E	SA	18	F
DH-14	Inter. - Plant Site				S	4	E	SA	2	E	SA 1989-97; P 1994-96	41	F
DH-15	Inter. - Plant Site				S	6	E	SA	2	E	SA	0	F
DH-16	Shallow Upgradient				S dry	0	E	SA dry	0	E	SA often dry	3	F
DH-17	Shallow Upgradient				S	4	E	SA 1988	2	E	SA	16	F
DH-18	Deep - Plant Site				S	4	E	SA 1988	3	E	SA	18	F
DH-19	Shallow - Plant Site				S 1987	2	E	SA	3	E	SA	18	F
DH-20	Shallow - Plant Site				S 1987	3	E	SA	4	E	SA 1989-97; P 1994-96	33	F
DH-21	Shallow - Plant Site				S 1987	3	E	SA	3	E	SA	18	F
DH-22	Shallow - Plant Site				S 1987	2	E	SA	3	E	SA	18	F
DH-23	Shallow - Plant Site				S 1987	2	E	SA	3	E	SA	18	F
DH-24	Shallow - Plant Site				S 1987	2	E	SA	3	E	SA	18	F
DH-26	Shallow - Plant Site				S 1987	2	E	SA	3	E	4/89	1	F
DH-27	Shallow - Plant Site				S 1987	2	E	SA	3	E	SA	20	F
DH-28	Shallow - Plant Site							SA	3	E	SA	20	F
DH-29	Shallow - Plant Site							SA	3	E	SA 1989-97; P 1994-96	33	F
East Helena Groundwater Monitoring Wells													
EH-50	Shallow - Downgradient				S	5	E	SA	3	E	SA	18	F
EH-51	Shallow - Downgradient				S	4	E	SA	4	E	SA	18	F
EH-52	Shallow - Downgradient				S	5	E	SA	4	E	SA	18	F
EH-53	Shallow - Downgradient				S	4	E	SA	3	E	SA	18	F
EH-54	Shallow - Downgradient				S	4	E	SA	4	E	SA	18	F
EH-57A	Shallow - Downgradient							SA	3	E	SA	18	F
EH-58	Shallow - Downgradient				S	4	E	SA	3	E	SA	18	F
EH-59	Shallow - Downgradient				S	3	E	SA	2	E	SA	15	F
EH-60	Shallow - Downgradient							SA	3	E	SA	18	F

TABLE 3-2-1. HISTORICAL SUMMARY OF THE WATER, SOIL AND SLAG SAMPLING PROGRAM

		Phase I			Phase II			Comp RI/FS			Post RI Monitoring		
		1984 to 1985			Fall 1986 - Spring/Summer 1987			Fall 1987 to Fall/Winter 1988			Spring 1989 to Fall/Winter 1997		
Site Code	Site Description	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]
East Helena Groundwater Monitoring Wells (Cont.)													
EH-61	Shallow - Downgradient							SA	3	E	SA	18	F
EH-62	Shallow - Downgradient							SA	3	E	SA	18	F
EH-100	Deep - Downgradient				S	4	E	SA	2	E			
EH-101	Inter. - Downgradient				S	6	E	SA	2	E			
EH-102	Inter. - Downgradient				S	5	E	SA	3	E	SA	18	F
Private Groundwater Monitoring Wells													
AMCHEM1	Deep - Downgradient							SA	2	E			
AMCHEM2	Deep - Downgradient	SA	3	A & B	SA	2	D & E	SA	2	E	SA	18	F
AMCHEM3	Deep - Downgradient	SA	2	A & B				4/88	1	E			
AMCHEM4	Deep - Downgradient				SA	2	D & E	12/88	1	E	SA	18	F
ASRWELL	Deep - Plant site				S 1987	3	D						
BERRY	Inter. - Downgradient	5/85	1	A	SA	2	D	4/88	1	E			
BRNHAM1	Inter. - Downgradient	SA	3	B & C									
CASEY	Inter. - Downgradient										5/89	1	F
COX	Well Info. Not Available							4/88	1	E			
DHULST	Inter. - Downgradient	SA	3	B & C	S	4	E	SA	2	E	SA	18	F
DUEL	Inter. - Downgradient	SA	3	A & B	SA	2	D	SA	2	E	SA	16	F
EHC1	Deep - Downgradient				S	4	D & E	4/88	1	E			
EHC2	Deep - Downgradient				S	3	D & E	4/88	1	E			
ERNST	Inter. - Downgradient	5/85	1	A	SA	2	D	SA	2	E			
FLAGE	Inter. - Downgradient	5/85	1	A				4/88	1	E			
HELFERT	Inter. - Downgradient	SA	3	A & B	SA	2	D & E	SA	2	E			
HOFF	Inter. - Downgradient	3/83, 10/83, 5/85	3	A	SA	2	D & E						
JENSEN A1	Inter. - Downgradient	10/83	1	A									
JENSEN A2	Inter. - Downgradient	5/85	1	C	SA	2	D & E	SA	2	E			
KAMRMN	Inter. - Downgradient				2/87	1	D & E						
KHULST	Inter. - Downgradient				S	2	E	7/88	1	E			
LAMPC	Inter. - Downgradient	SA	4	B & C									
LAMPF1	Inter. - Downgradient	SA	2	A & B									
LAMPR	Inter. - Downgradient	SA 1985	2	A	SA	2	D	4/88	1	E			
LHULST	Inter. - Downgradient				S	2	E	SA	2	E	SA	18	F
MANION	Inter. - Downgradient	SA	5	A & C	SA	2	D						
MCD1	Inter. - Downgradient	SA	3	A & B									
NORDSTR	Inter. - Downgradient	5/85	1	A	SA	2	D						
ROMASKO	Inter. - Downgradient	5/85	1	A	SA	2	D	SA	2	E			
SIMAC	Inter. - Downgradient				SA 1987	2	E	SA	2	E			
STCLAIR	Shallow - Downgradient				4/87	1	D	SA	2	E	SA often dry	9	F
VETSCH	Inter. - Downgradient	5/85	1	A	SA	2	D & E	SA	2	E			
WALTER	Inter. - Downgradient				2/87	1	E	SA	3	E	SA 1989-90	3	F
WESTON	Inter. - Downgradient	5/85	1	A	SA	2	D	SA	2	E			
WOJCIK	Inter. - Downgradient	5/85	1	A	SA	2	D	SA	2	E			
Plant Process Fluids													
AP-1	Acid Plant Treatment Facility							P	6	E			
AP-2	Acid Plant Treatment Facility				P 1987	2	D	P	4	E			
AP-3	Acid Plant Treatment Facility							P	4	E			
APTF	Acid Plant Treatment Facility										P 4/93	1	F
AS\W\SUMP1	Acid Plant Demolition										5/98	1	See Table 3-2-8
AS\W\SUMP2	Acid Plant Demolition										5/98	2	See Table 3-2-8
AS\W\SUMP3	Acid Plant Demolition										5/98	3	See Table 3-2-8
EHSE	Sewage Out							8/88		E			
EHSI	Sewage In							8/88		E			
LH-13	Lower Lake										4/92	1	See Table 3-2-5
LH-18	Lower Lake										4/92	1	See Table 3-2-5
LH-42	Lower Lake										4/92	1	See Table 3-2-5
LH-52	Lower Lake										4/92	1	See Table 3-2-5

TABLE 3-2-1. HISTORICAL SUMMARY OF THE WATER, SOIL AND SLAG SAMPLING PROGRAM

		Phase I			Phase II			Comp RI/FS			Post RI Monitoring		
		1984 to 1985			Fall 1986 - Spring/Summer 1987			Fall 1987 to Fall/Winter 1988			Spring 1989 to Fall/Winter 1997		
Site Code	Site Description	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]
Plant Process Fluids (Cont.)													
LH-48	Lower Lake										4/92	1	See Table 3-2-5
LL-1	Composite of Lower Lake - 1a, 1b & 1c				P 5/87	1	E	FALL 1987	4	E			
LL-2	Lower Lake - 2				P 5/87	2	E	FALL 1987	4	E			
LL-1D	Lower Lake Deep										P 1994-96	27	F
LL-1S	Lower Lake Surface										P 1994-96	40	F
LOWER LAKE	Lower Lake	P 1984-85	4	A	S	3	D & E				SA 1994-97	18	F
S-1	Sump (Ore Storage Area)				P	2	E	P	5	E			
S-2	Sump (South Plant Drain)				P	2	E	P	5	E			
S-3	Sump (Ore Storage Area)							P	5	E			
SHOWER	SHOWER							P 8/88	1	E			
SP-1	Speiss Pond				P	2	E	P	4	E			
SP-2	Speiss Pond				5/87	1	E						
SP-3	Speiss Pond										SA 1991-97	0/Dry	
SP-4	Speiss Pond										SA 1991-97	0/Dry	
SP-5	Speiss Pond										SA 1991-97	0/Dry	
ST-1	Sinter Plant				5/87	1	E	P	5	E			
ST-2	Sinter Plant							P	5	E			
TRWASH	Truch Wash Drain				P 5/87	1	E						
TT-1	Thornock Lake	P 1984-85	4	A	P 7/87	1	E	P	5	E			
WASHER	Washing Machine Drain							P 8/88	1	E			
ZP-1	Zinc Plant Drain							FALL 1987	4	E			
Surface Water													
PPC-3	Prickly Pear Creek	P 1984-85	8	A & B	S	5	D				SA 1989-97; P 1994-96	69	F
PPC-3A	Prickly Pear Creek (Sample Site Change)										SA 1996-97	5	F
PPC-4	Prickly Pear Creek	P 1984-85	8	A & B	S	3	D				P 1995-96	38	F
PPC-5	Prickly Pear Creek	P 1984-85	8	A & B	S	3	D				SA 1989-97; P 1994-96	62	F
PPC-6	Prickly Pear Creek	P 1984-85	8	A & B	S	3	D				P 1995	26	
PPC-7	Prickly Pear Creek	P 1984-85	8	A & B	S	3	D				SA 1989-97; P 1995	47	F
PPC-8	Prickly Pear Creek	P 1984-85	8	A & B	S	3	D				SA	18	F
PPC-9	Prickly Pear Creek	P 1984-85	8	A & B	S	3	D						
PPC-29A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-30A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-31A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-32A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-33A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-34A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-35A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-36A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-37A	Prickly Pear Creek Synoptic Run				S	2	D						
PPC-38A	Prickly Pear Creek Synoptic Run				S	3	D						
PPC-40A	Prickly Pear Creek Synoptic Run				S	2	D						
PPC-101	Prickly Pear Creek										P 1994-97	27	F
PPC-102	Prickly Pear Creek										P 1994-97	27	F
PPC-103	Prickly Pear Creek										P 1994-97	27	F
SITEA	Storm Water Runoff - Off Plant	5/85	1	C	P 7/87	1	E						
SITEE	Storm Water Runoff - Off Plant				P 7/87	1	E						
SITEF	Storm Water Runoff - Off Plant				P 7/87	1	E						
SITEG	Storm Water Runoff - Off Plant				P 7/87	1	E						
SITEH	Storm Water Runoff - Off Plant				P 7/87	1	E						
UPPER LAKE	Upper Lake	P 1984-85	4	A									

TABLE 3-2-1. HISTORICAL SUMMARY OF THE WATER, SOIL AND SLAG SAMPLING PROGRAM

		Phase I			Phase II			Comp RI/FS			Post RI Monitoring		
		1984 to 1985			Fall 1986 - Spring/Summer 1987			Fall 1987 to Fall/Winter 1988			Spring 1989 to Fall/Winter 1997		
Site Code	Site Description	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]
Surface Water (Cont.)													
WD-1	Wilson Ditch	5/85	1	B									
WD-2	Wilson Ditch	P 1984-85	22	B							P 5/93	2	E
WD-3	Wilson Ditch	5/83	1	B							P 5/93	1	E
WD-4	Wilson Ditch										P 5/93	1	E
Plant Site Monitoring Well Drill Hole Soils													
APSD-1	Well Site Drill Hole										8/91	8	See Table 3-2-9
APSD-2	Well Site Drill Hole										8/91	10	See Table 3-2-9
APSD-3	Well Site Drill Hole										8/91	5	See Table 3-2-9
APSD-4	Well Site Drill Hole										8/91	7	See Table 3-2-9
APSD-7	Well Site Drill Hole										10/93	5	arsenic, lead, cadmium, zinc
APSD-8	Well Site Drill Hole										10/93	6	arsenic, lead, cadmium, zinc
APSD-9	Well Site Drill Hole										10/93	8	arsenic, lead, cadmium, zinc
APSD-10	Well Site Drill Hole										10/93	8	arsenic, lead, cadmium, zinc
APSD-11	Well Site Drill Hole										10/93	7	arsenic, lead, cadmium, zinc
APSD-12	Well Site Drill Hole										10/93	6	arsenic, lead, cadmium, zinc
APSD-13	Well Site Drill Hole										10/93	12	arsenic, lead, cadmium, zinc
APSD-14	Well Site Drill Hole										10/93	6	arsenic, lead, cadmium, zinc
DH-1	Well Site Drill Hole	11/84-12/84	6	G				12/87	6	H			
DH-2	Well Site Drill Hole	11/84-12/84	6	G				12/87	7	H			
DH-3	Well Site Drill Hole	11/84-12/84	4	G				12/87	6	H			
DH-4	Well Site Drill Hole	11/84	2	G									
DH-5	Well Site Drill Hole	11/84	2	G									
DH-6	Well Site Drill Hole	11/84	2	G				12/87	6	H			
DH-7	Well Site Drill Hole	12/84	2	G				12/87	6	H			
DH-8	Well Site Drill Hole	12/84-1/85	6	G									
DH-9	Well Site Drill Hole	11/84	2	G									
DH-10	Well Site Drill Hole	11/84	1	G				12/87	6	H			
DH-11	Well Site Drill Hole	1/85	1	G				12/87	6	H			
DH-13	Well Site Drill Hole				11/86	8	Sequential Extraction & Totals - H	12/87	6	H			
DH-14	Well Site Drill Hole				10/86	5	Sequential Extraction & Totals - H	12/87	5	H			
DH-15	Well Site Drill Hole				10/86	5	Sequential Extraction & Totals - H						
DH-16	Well Site Drill Hole				11/86	5	Sequential Extraction & Totals - H						
DH-17	Well Site Drill Hole				11/86	3	Sequential Extraction & Totals - H						
DH-18	Well Site Drill Hole				12/86	4	H						
DH-19	Well Site Drill Hole				4/87	9	H						
DH-20	Well Site Drill Hole				4/87	9	H						
DH-21	Well Site Drill Hole				4/87	9	SVOA[3] & H						
DH-22	Well Site Drill Hole				4/87	10	H						
DH-23	Well Site Drill Hole				4/87	6	H						
DH-24	Well Site Drill Hole				4/87	10	H						
DH-25	Well Site Drill Hole				4/87	8	SVOA[3] & H						
DH-26	Well Site Drill Hole				5/87	8	SVOA[3] & H						
DH-27	Well Site Drill Hole							12/87	9	H			
DH-28	Well Site Drill Hole							12/87	8	H			
DH-29	Well Site Drill Hole							12/87	7	H			

TABLE 3-2-1. HISTORICAL SUMMARY OF THE WATER, SOIL AND SLAG SAMPLING PROGRAM

		Phase I			Phase II			Comp RI/FS			Post RI Monitoring		
		1984 to 1985			Fall 1986 - Spring/Summer 1987			Fall 1987 to Fall/Winter 1988			Spring 1989 to Fall/Winter 1997		
Site Code	Site Description	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]
East Helena Groundwater Monitoring Well Drill Hole Soils													
EH-57	Well Site Drill Hole				5/87	10	H						
EH-59	Well Site Drill Hole				5/87	7	H						
EH-60	Well Site Drill Hole							12/87	2	H			
EH-61	Well Site Drill Hole							11/87	7	H			
EH-100	Well Site Drill Hole				11/86	10	Sequential Extraction & Totals - H						
EH-101	Well Site Drill Hole				10/86	4	Sequential Extraction & Totals - H						
EH-102	Well Site Drill Hole				11/86	4	Sequential Extraction & Totals - H						
Plant Site Soil Samples Not Associated With Well Sites													
ASEX-SW-1	Acid Plant Demolition Surface Samples										4/93	1	See Table 3-2-8
ASEX-HDS-1	Acid Plant Demolition Surface Samples										4/93	1	See Table 3-2-8
ASEX-HDS-2	Acid Plant Demolition Surface Samples										4/93	1	See Table 3-2-8
APSD-5	Core Sample										8/91	8	See Table 3-2-3
APSD-6	Core Sample										8/91	7	See Table 3-2-3
AS\S\1EXC	Acid Plant Post Excavation Samples										5/93	1	See Table 3-2-8
C-56 thru C-106	Lower Lake Core Samp.										4/95	121	See Table 3-2-5
LH-1	Lower Lake Core Samp.							10/87	6	H			
LH-2	Lower Lake Core Samp.							10/87	8	H			
LH-3	Lower Lake Core Samp.							11/87	8	H			
LH-4	Lower Lake Core Samp.							11/87	9	H			
LH-5	Lower Lake Core Samp.							11/87	8	H			
LH-6	Lower Lake Core Samp.							11/87	7	H			
LH-8	Lower Lake Core Samp.										10/91	1	See Table 3-2-5
LH-11	Lower Lake Core Samp.										10/91	1	See Table 3-2-5
LH-13	Lower Lake Core Samp.										10/91, 4/92	2	See Table 3-2-5
LH-18	Lower Lake Core Samp.										10/91	1	See Table 3-2-5
LH-20	Lower Lake Core Samp.										10/91, 4/92	2	See Table 3-2-5
LH-26	Lower Lake Core Samp.										10/91	1	See Table 3-2-5
LH-28	Lower Lake Core Samp.										10/91	1	See Table 3-2-5
LH-31	Lower Lake Core Samp.										10/91	1	See Table 3-2-5
LH-34	Lower Lake Core Samp.										5/92, 8/92, 10/92	7	See Table 3-2-5
LH-37	Lower Lake Core Samp.										5/92, 8/92	2	See Table 3-2-5
LH-38	Lower Lake Core Samp.										5/92	1	See Table 3-2-5
LH-41	Lower Lake Core Samp.										5/92, 8/92	2	See Table 3-2-5
LH-42	Lower Lake Core Samp.										5/92, 8/92	2	See Table 3-2-5
LH-46	Lower Lake Core Samp.										5/92	1	See Table 3-2-5
LH-47	Lower Lake Core Samp.										5/92, 8/92	2	See Table 3-2-5
LH-49	Lower Lake Core Samp.										5/92, 8/92	2	See Table 3-2-5
LH-52	Lower Lake Core Samp.										4/87	1	See Table 3-2-5
LH-54	Lower Lake Core Samp.										5/92, 8/92	2	See Table 3-2-5
LLB-1	Lower L. Boundry Core										11/90	4	See Table 3-2-3
LLB-2	Lower L. Boundry Core										11/90	4	See Table 3-2-3
LLB-3	Lower L. Boundry Core										11/90	3	See Table 3-2-3
LLB-4	Lower L. Boundry Core										11/90	4	See Table 3-2-3
LLB-5	Lower L. Boundry Core										11/90	2	See Table 3-2-3
LLB-6	Lower L. Boundry Core										11/90	3	See Table 3-2-3
LLB-7	Lower L. Boundry Core										11/90	2	See Table 3-2-3
LLB-8	Lower L. Boundry Core										11/90	2	See Table 3-2-3
LOWERLKSED	Lower Lake Sediment	11/84	1	G									
APSD-P1 thru APSD-P9	Acid Plant Sediment Drying Area Pit Samples										8/96-9/96	7	See Table 3-2-9
Pile #3 thru Pile #119	Lower Ore Storage Area Pit Samples										10/94	100	See Table 3-2-3
S-3SED	Sump Lower Ore Storage Area Sediment							10/87	1	H			

TABLE 3-2-1. HISTORICAL SUMMARY OF THE WATER, SOIL AND SLAG SAMPLING PROGRAM

		Phase I			Phase II			Comp RI/FS			Post RI Monitoring		
		1984 to 1985			Fall 1986 - Spring/Summer 1987			Fall 1987 to Fall/Winter 1988			Spring 1989 to Fall/Winter 1997		
Site Code	Site Description	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]	Sampling Intervals [1]	Tot. No. of Samp.	Parameter Schedule [2]
Plant Site Soil Samples Not Associated With Well Sites (Cont.)													
SC-1	Soil Core Samples from Various Sites							11/87	2	H			
SC-2	Soil Core Samples from Various Sites							11/87	3	H			
SC-3	Soil Core Samples from Various Sites							12/87	10	H			
SC-4	Soil Core Samples from Various Sites							12/87	9	H			
SC-5	Soil Core Samples from Various Sites							12/87	7	H			
SP-1SED	Speiss Pond Sediment							11/87	1	H			
SPIT-1	Speiss Pit Post Excavation Samples										7/95	1	arsenic, cadmium, copper, lead, zinc
SPIT-2	Speiss Pit Post Excavation Samples										7/95	1	arsenic, cadmium, copper, lead, zinc
SP-SS-1 thru SP-SS-9	Speiss Pond Core Samples										7/89	87	arsenic, cadmium, copper & lead (EPTOX only)
SS-1 thru SS-31 [4]	Plant Site Surface Soil Samples							1987	26	See Table 4-1-1			
ST-2SED	Sinter Plant Sediment							10/87	1	H			
TH-1	Thornock L. Core Samp.							12/87	4	H			
TH-2	Thornock L. Core Samp.							12/87	8	H			
TL-001 thru TL-009	Thornock Lake Surficial										12/91	9	See Table 3-2-7
TL-3	Thornock L. Sediment										6/91	6	See Table 3-2-7
TL-4	Thornock L. Sediment										6/91	6	See Table 3-2-7
TREATSLUDG	Lower Lake Sludge										6/92	1	See Table 3-2-5
TT-1SED	Thornock Lake Sediment	11/84	1	G				10/87	1	H			
Soils Samples Associated With Surface Water Sites													
PPC-3SED	Prickly Pear Cr. Sediment	11/84,5/85	2	G									
PPC-4SED	Prickly Pear Cr. Sediment	11/84,5/85	2	G									
PPC-5SED	Prickly Pear Cr. Sediment	11/84,5/85	2	G									
PPC-6SED	Prickly Pear Cr. Sediment	11/84,5/85	2	G									
PPC-7SED	Prickly Pear Cr. Sediment	11/84,5/85	2	G									
PPC-8SED	Prickly Pear Cr. Sediment	11/84,5/85	2	G									
PPC-9SED	Prickly Pear Cr. Sediment	11/84,5/85	2	G									
UPPERLKSED	Upper Lake Sediment	11/84	1	G									
WD-2SED	Wilson Ditch Sediment	11/84	1	G									
WD-3SED	Wilson Ditch Sediment	11/84	1	G									
WD-2	Wilson Ditch Pit Samples							12/87	4	H			
WD-3	Wilson Ditch Pit Samples							12/87	4	H			
WD-4	Wilson Ditch Pit Samples							12/87	4	H			
WD-5	Wilson Ditch Pit Samples							12/87	4	H			
WD-A (PRE)	Wilson Ditch Proper Pit Samples										2/93, 4/93	94	arsenic, lead, cadmium
WD-A (PST)	Wilson Ditch Sediment										4/93-4/94	146	arsenic, lead, cadmium
WD-B (PST)	Wilson Ditch Spur Sediments										4/93	13	arsenic, lead, cadmium
WD-C (PST)	New Wilson Ditch Soil										4/93-5/93	19	arsenic, lead, cadmium
Slag													
FSLAG	Slag Pile Leachate				P 1986-87	6	H						
USLAG	Slag Pile Leachate				P 1986-87	5	H						

Notes:
1) A = Annual Sampling; SA = Semi-Annual Sampling; S = Seasonal; and P = Periodic Sampling.
2) Refer to Table 3-2-2. Sampling Parameter Schedule
3) SVOA = Semi-Volatile Organic Analysis
4) Refer to Table 4-1-1 for data. Hydrometrics did not collect these samples, therefore, data is not in Appendix 3-1-3.

TABLE 3-2-2. SAMPLE PARAMETER SCHEDULE

	Schedules								
	A	B	C	D	E	F	G	H	I
Parameter	Complete [1]	Partial [1]	Special A [1]	Standard[2]	Special B [2]	Special C [3]	Phase I Soils [1]	Post Phase I Soils [2]	Slag [2]
Physical Parameters									
Specific Conductivity (field & lab)	X	X	X	X	X	X			
pH (fld & lab)	X	X	X	X	X	X			
Depth to Water Level or Flow	X [4]	X [4]	X [4]	X	X	X			
Total Dissolved Solids	X	X	X	X	X	X			
Total Suspended Solids (Surface Water Only)	X	X	X	X	X	X			
Dissolved Oxygen	X [4]	X [4]	X [4]	X	X	X			
Temperature	X [4]	X [4]	X [4]	X [4]	X [4]	X			
Ions and Cations									
Sulfate	X		X	X	X	X			
Chloride	X		X		X	X			
Total Alkalinity as $CaCO_3$	X		X		X	X [5]			
Bicarbonate	X		X	X	X	X [5]			
Calcium	X		X		X	X [5]			
Magnesium	X		X		X	X [5]			
Sodium	X		X		X	X [5]			
Potassium	X		X		X	X [5]			
Arsenic and Metals (total and dissolved for surface water; dissolved for ground water)									
Aluminum			X						
Antimony			X				X		
Arsenic	X	X	X	X	X	X	X	X	X
Arsenic III					X[6]	X			
Arsenic V					X[6]	X			
Barium			X				X		X
Beryllium			X						
Cadmium	X	X	X	X	X	X	X	X	X
Chromium			X				X		X
Cobalt			X				X		
Copper	X		X		X	X	X	X	X
Iron	X		X	X	X		X	X	X
Iron II					X[6]				
Iron III					X [7]				
Lead	X	X	X	X	X		X	X	X
Manganese	X		X		X	X	X		X
Mercury			X				X		X
Nickel			X					X	
Selenium			X						X
Silver			X				X		X
Thallium			X						
Tin			X						
Vanadium			X				X		
Zinc	X	X	X	X	X	X	X	X	X
Organics									
Volatile Organics [8]					X	X	X		
Semi-Volatile Organics [9]					X	X	X		
Fuel Hydrocarbons (Gas & Diesel)[10]					X	X			

Notes: 1) ASARCO and Hydrometrics, 1984. Hydrogeological Investigation of the Asarco East Helena Plant, Water Resources Monitoring Plan, June 29,1984.

2) Hydrometrics, 1986. Water Resources Investigation ASARCO East Helena Plant - Phase II, Remedial Investigation Work Plan, August, 1986; and
Hydrometrics and MDI, 1987. Comprehensive Remedial Investigation/Feasibility Study Plan, ASARCO, East Helena, Montana.

3) Variation of Special B analyte list used for the Post RI/FS Sampling.

4) Required by Work Plan but was not consistantly recorded.

5) Analyzed in the Spring only for Plant Process Plant Fluids, Ground Water and Private Well samples.

6) Not analyzed in Plant Process Fluids.

7) Required by Work Plan but was not analyzed.

8) EPA Method 624, Target Compound List - Only analyzed for sites DH-13, EH-60 and EH-61.

9) EPA Method 625, Target Compund List, Only analyzed for sites DH-13, DH-17(1 sample event), DH-24(1 sample event), EH-60 and EH-61.

10) Only analyzed for sites, DH-13, DH-24, EH-60 and EH-61, EH-62. Carbon analyses for Site DH-27 & DH-28, starting Fall 1996.

11) Hydrometrics, 1986. Water Resources Investigation Asarco East Helena Plant - Phase II, Remedial Investigation Work Plan, August 1986. Sampled during construction phase only.

~~were collected by Asarco for information purposes and were not part of an established work plan.~~

~~Borehole samples were taken at sites APSD-5 and APSD-6 in August of 1991. These samples were sent to Asarco's Technical Services Center in Salt Lake City (TSC-SLC) for Extraction Procedure Toxicity (EPTOX) tests and the leachate was tested for arsenic and metals.~~

~~Soil and leachate samples were analyzed according to each laboratories' analytical plan (LAP) and quality assurance plan (QAP). The results for these samples were not validated.~~

~~Table 3-2-3 summarizes sampling conducted in the areas between Upper Lake, Lower Lake and Prickly Pear Creek.~~

3.2.2.2 Subsurface Soils

Post RI/FS sampling of subsurface soils was conducted in conjunction with the implementation of remedial measures for Lower Lake, the former Thornock Lake area, the Speiss Pond area, and the acid plant water treatment facility. The data collection associated with remedial activities in each of these areas is described in Section 3.2.3. Additional subsurface soils characterization was also conducted in the Acid Plant sediment drying area and in the area between Upper and Lower Lakes. This included soils data from test pits, soil borings and installation of monitoring wells.

In November of 1990, soil samples were taken at eight test pit sites (LLB-1 through LLB-8) in the area between Upper and Lower Lake in order to characterize the soils. Each site was sampled at the following intervals: 0-1 ft., 2-3 ft., 3-5 ft., and 9-10 ft. Samples were analyzed for Toxic Characteristic Leaching Procedure (TCLP) and total arsenic and metals. These data were collected by Asarco for information purposes and were not part of an established work plan.

Borehole samples were taken at sites APSD-5 and APSD-6 in August of 1991. These samples were sent to Asarco's Technical Services Center in Salt Lake City (TSC-SLC) for Extraction Procedure Toxicity (EPTOX) tests and the leachate was tested for arsenic and metals.

Soil and leachate samples were analyzed according to each laboratories' analytical plan (LAP) and quality assurance plan (QAP). The results for these samples were not validated.

Table 3-2-3 summarizes sampling conducted in the areas between Upper Lake, Lower Lake and Prickly Pear Creek.

TABLE 3-2-3. AREAS BETWEEN UPPER LAKE AND LOWER LAKE, LOWER LAKE AND PRICKLY PEAR CREEK, AND LOWER ORE STORAGE AREA SAMPLING SUMMARY

	LLB-1 thru LLB-8 Pit Soil 24 Samples		APSD-5 and 6 Drill Hole Soils 15 Samples	Pile#3-Pile #119 (Stockpiles) 100 Samples
Parameter	**TCLP**	**Total**	**EPTOX**	**XRF**
Arsenic	X	X	X	X
Barium	X		X	
Cadmium	X	X	X	
Chromium	X		X	
Iron		X		
Lead	X	X	X	X
Manganese		X		
Mercury	X		X	
Selenium	X		X	
Silver	X		X	
Zinc		X		

4. EVALUATION OF CURRENT CONDITIONS

As described in Sections 1.0 and 3.0, data from the plant site surface soils, process fluids, surface water, slag and ore storage operable units were obtained and evaluated as part of the Process Ponds RI/FS (Hydrometrics, 1989) and the Comprehensive RI/FS (Hydrometrics, 1990a). Additional data were collected as part of post-RI monitoring efforts from 1990 through 1998, the RD/RA efforts for process ponds and other non-CERCLA activities. In this section, current soil and water quality trends are examined within the plant site and along potential migration pathways.

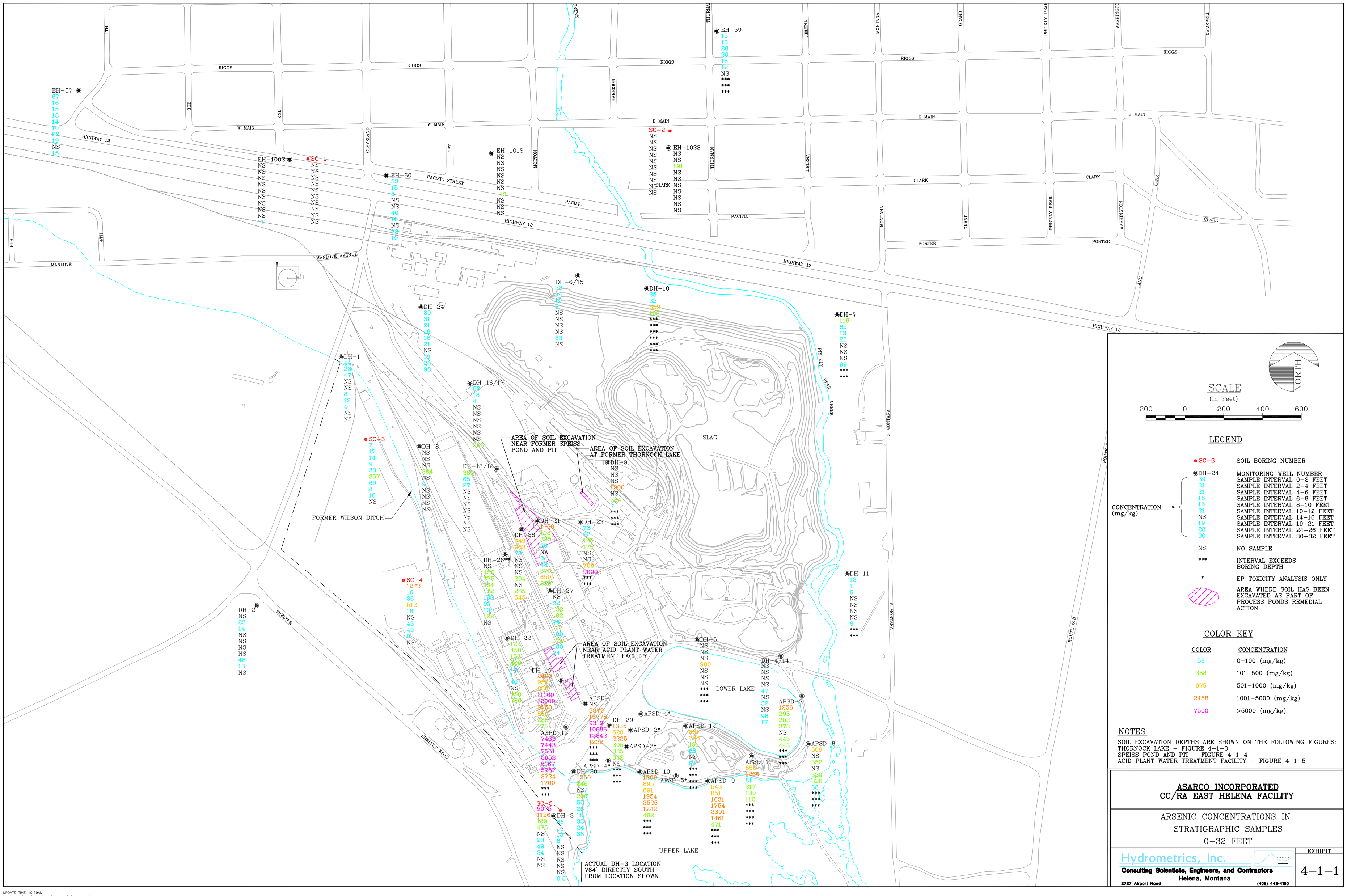
4.1 PLANT SITE SOILS AND ORE STORAGE AREAS

The evaluation of surface soils, subsurface soils and the ore storage areas includes discussion of on-site surface soils, stockpiles and slag. Process pond sediments are addressed separately in Section 4.2, surface water bottom sediments in Section 4.3 and subsurface sediment stratigraphy and quality in Section 4.4.

4.1.1 Surface Soils

Plant site surface soils were addressed as part of the Comprehensive RI/FS (Hydrometrics, 1990a). The plant site surface soil investigation focused primarily on ore storage areas in the plant and other unpaved areas at various locations.

Surface soil samples (0-4 inch depth) were collected during installation of monitoring wells at nine sites (see Figure 4-1-1). Surface soil samples (0-1 inch depth) were also collected at 26 other plant site locations (see Figure 4-1-1). The areas sampled for surface soils (0-1 inch depth) included the former Upper Ore Storage Area (4 samples), the Lower Ore Storage Area (5 samples), railroad tracks east and south of the Thawhouse (7 samples), the perimeter of the slag pile (4 samples), other unpaved areas within the main facility (4 samples) and unpaved areas outside of the main facility (2 samples).



UPDATE TIME: 10:59AM
007_0867\D65\0127\HEL\011599\I:\STORAGE\86799A02.DWG

The sampling methodology used at the surface soil sampling sites is described in detail in the Comprehensive RI/FS (Hydrometrics, 1990a). In general, three samples were collected around a center stake and composited into one sample at each location. The samples were analyzed for the 12 metals shown in Table 4-1-1. A statistical summary of the data is in Table 4-1-2. Arsenic, cadmium, copper, lead and zinc concentrations in surface soils are shown for both surface soil sampling sites and monitoring well locations on Figure 4-1-1.

All of the metals analyzed in plant site soils were elevated compared to background values (see Table 4-1-2). Of the metals analyzed arsenic, cadmium, copper, lead and zinc had the highest concentrations. The highest concentrations of arsenic, cadmium and lead were from samples collected in the Upper Ore Storage Area and the railroad tracks east and south of the Thawhouse. The lowest concentrations were from samples collected from the perimeter of the slag pile and unpaved areas outside of the plant site.

In the RI (Hydrometrics, 1990a), an analysis of variance (ANOV) was calculated to test differences between geometric mean concentrations of metals for different use areas on the plant site. The least significant difference (LSD) method of multiple comparisons was then used to separate the means. Table 4-1-3 shows the results of the analysis.

4.1.2 Subsurface Soils

Plant site subsurface soils were addressed as part of the Comprehensive RI/FS (Hydrometrics 1990a). During the RI, subsurface samples were collected from 50 soil boring and monitoring well locations on the site (see Exhibit 4-1-1). Since completion of the RI (1990) supplemental subsurface soil data has been obtained as part of post-RI remedial activities for the Process Ponds. The post-RI subsurface data include collection of sample cores from Lower Lake, Former Thornock Lake, the Speiss Pond and Pit areas, the former Acid Plant Water Treatment Facility settling pond, and the Acid Plant Sediment Drying Areas.

Table 4-1-1 - Surface Soil Sample Results - 1987 Phase II Investigation

	Parameter											
Station #	**Ag**	**As**	**Cd**	**Cu**	**Hg**	**Cr**	**Mn**	**Pb**	**Sb**	**Se**	**Tl**	**Zn**
SS-1	--	6075	6000	14575	240	22	1590	19350	980	423	182	23625
SS-2	209	3475	1813	3225	236	20	230	24975	107	518	118	10050
SS-3	64	1078	413	1090	--	19	400	10875	5	69	35	3075
SS-4	193	5650	14725	12175	104	23	890	23625	783	186	280	44050
SS-5	199	1495	1093	8850	2.2	27	--	21875	53	13	33	46625
SS-6	124	3300	253	4200	9.2	14	453	19400	5	13	59	3975
SS-7	157	3400	373	8500	4.5	12	195	22350	508	19	57	43725
SS-8	185	3800	1013	18600	15	30	1285	21400	189	71	29	14250
SS-10	197	3900	1613	8350	12	38	1823	23900	197	17	52	30425
SS-11	169	6525	5800	20700	17	36	2353	22100	1970	113	103	67175
SS-12	186	35500	5325	31450	--	27	2445	19975	1395	97	86	63650
SS-14	63	1098	212	1918	0.97	12	308	8900	206	21	9.9	30125
SS-15	30	385	172	9750	2	29	1858	3250	5	13	9.9	3975
SS-16	14	121	92	16375	0.75	14	338	1368	5	13	9.9	1868
SS-17	74	795	212	1813	0.87	15	220	6200	129	13	12	2235
SS-18	174	13450	23400	29200	70	86	2018	19325	2260	498	515	67175
SS-19	199	21625	2373	19850	--	46	11700	20250	1943	99	74	23300
SS-20	179	5450	1733	18625	0.6	27	1615	19225	2850	31	63	26275
SS-21	211	17075	1693	35350	--	79	950	22575	4950	221	52	14875
SS-22	201	3100	2213	11300	0.87	13	1083	21950	1770	13	76	23625
SS-23	12	121	212	320	--	26	410	11600	5	13	14	1093
SS-24	169	2115	613	4275	19	18	--	16575	5	13	33	7325
SS-28	214	8625	2525	23600	360	15	1703	1535	--	320	220	23925
SS-29	174	9525	2575	23700	90	27	2600	20300	4125	142	278	48550
SS-30	199	1633	373	5600	4	15	1510	12725	425	15	25	7925
SS-31	167	2625	813	6900	4.7	27	660	14600	81	33	27	84650

Notes: All concentrations reported in ug/g (dry wt.).
Surface soil refers to soil sampled at a depth of 0-1 inches.

Table 4-1-2 - Statistical Summary of Soil Samples - 1987 Phase II Investigation

Element	N[1]	Arithmetic Mean	Standard Deviation	Minimum Value	Maximum Value	Geometric Mean	Geo. Mean[2] Background	Enrichment Factor[3]
Ag	25	150.5	65.9	12.0	214.0	122.1	0.20	610.6
As	26	6228.5	7977.8	121.0	35500.0	2987.3	16.50	181.0
Cd	26	2985.8	5176.2	92.0	23400.0	1127.5	0.24	4697.7
Cr	26	27.6	18.3	12.0	86.0	23.8	15.30	1.6
Cu	26	13088.1	9953.9	320.0	35350.0	8488.3	16.30	520.8
Hg	21	56.8	100.0	0.6	360.0	9.9	0.08	124.2
Mn	24	1609.9	2283.8	195.0	11700.0	968.9	336.00	2.9
Pb	26	16546.3	7213.2	1368.0	24975.0	13552.4	11.60	1168.3
Sb	25	998.0	1365.5	5.0	4950.0	193.5	0.27	716.5
Se	26	115.3	155.2	13.0	518.0	49.1	0.07	701.2
Tl	26	94.3	116.0	9.9	515.0	52.9	0.09	588.2
Zn	26	27597.9	23891.5	1093.0	84650.0	16043.8	46.90	342.1

Notes: All concentrations reported in ug/g (dry wt.).
Surface soil refers to soil sampled at a depth of 0-1 inches.

Footnote: (1) Unequal sample sizes due to rejection of some data during data validation process.
(2) Source: Comprehensive RI/FS Report (Hydrometrics, 1990a)
(3) Enrichment factor = geometric mean plant soils / geometric mean background.

Table 4-1-3 - Geometric Means of Soil Samples by Area

Element[1]	Upper Ore Storage Area	Lower Ore Storage Area	R.R. Tracks East & South of Thawhouse	Perimeter of Slag Pile	Misc. Bare Areas within Main Facility	Misc. Bare Areas Outside Main Facility
Ag	137.1 B	169.8 B	162.9 B	45.8 A	196.3 B	45.1 A
As	3365 BC	3013 B	9057 C	605.3 A	4519 BC	505.8 A
Cd	2851 C	699.8 AB	2710 C	228.6 A	1521 BC	360.3 AB
Cr	20.9 A	22 AB	38.4 B	19.1 A	16.7 A	21.6 AB
Cu	5000 A	8670 BC	17219 C	6776 BC	13709 C	1169 A
Hg	180.7 B	6.96 A	4.99 A	1.62 A	18.3 A	19 AB
Mn	601.2 A	674.5 A	1726 A	598.4 A	1641 A	410.2 A
Pb	18750 BC	21727 C	17298 BC	4898 A	9661 AB	13868 BC
Sb	142.2 B	87.1 B	1556 C	25.4 AB	1459 C	5 A
Se	230.1 C	20.8 A	90.2 BC	18.5 A	54.6 AB	13 A
Tl	120.5 D	44.2 BC	75 CD	12.7 A	103.8 CD	21.5 AB
Zn	13397 A	20370 A	24831 A	11722 A	21577 A	2831 A

Notes: All concentrations reported in ug/g (dry wt.).
Surface soil refers to soil sampled at a depth of 0-1 inches.

Footnote: (1) Letters A, B, C & D represent statistical groupings. Values within same element (rows) followed by same letter not significantly different at P = 0.10.

4.1.2.1 RI/FS Subsurface Soil Data

During the RI, subsurface samples were collected from 45 soil borings at monitoring well locations during well construction. Supplemental subsurface data were also collected from test pit locations at nine of the monitoring well sites (DH-1, DH-2, DH-3, DH-6, DH-7, DH-10, DH-11, DH-13 and DH-17), and from 5 soil core locations (SC-1 through SC-5) which were not completed as monitoring wells. With the exception of the test pit locations, soil samples were collected at two foot increments to a depth of 10 feet using split-spoons, with additional sampling conducted at 5 foot intervals to the depth of completion. At test pit locations, additional increments were sampled (0-4 inches, 4-8 inches, 8-12 inches, 1-2 feet, 2-3 feet, 3-4 feet and 4-5 feet) to a depth of 5 feet. The number of samples analyzed at individual sites varies, depending on the depth of completion and sample recovery rates. Subsurface soil samples collected during the RI were analyzed for total arsenic and metals. Sampling intervals and soil analytical results are shown in the soil quality database in Appendix 3-1-3. Exhibits 4-1-1, 4-1-2 and 4-1-3 present the soil quality data for arsenic, cadmium and lead at each sampling location.

As shown in Exhibit 4-1-1, arsenic concentrations in subsurface soil vary from less than 100 mg/kg to greater than 10,000 mg/kg within the plant site area. The highest concentrations of arsenic (above 5000 mg/kg) were in the southern half for the site in the former acid plant sediment drying areas, at DH-19, ASPD-13 and ASPD-14 near the former Acid Plant Water Treatment Facility. Elevated concentration of arsenic (above 1000 mg/kg) also was observed in fill material in the area between Upper Lake and Lower Lake. Arsenic concentrations in excess of 1000 mg/kg were also detected in shallow soils from the southern end of the lower ore storage yard (SC-4), and in soils at DH-21, DH-9 and DH-23. Arsenic concentrations are generally less than 500 mg/kg in the subsurface soils on the northern half of the plant site and in the East Helena area.

Many of the sampling locations in the plant site area show a progressive decrease in arsenic concentration with depth and then an increase again at the water table (Figure 4-1-2). The

concentration increase within the saturated zone is an indication of lateral transport and attenuation processes within the aquifer. As shown in Figure 4-1-2, these increased concentrations generally extend only 10 to 15 feet beneath the water table.

Cadmium concentrations in subsurface soil range from less than 1 mg/kg to greater than 1000 mg/kg (Exhibit 4-1-2). Similar to the pattern observed for arsenic, the highest cadmium concentrations (greater than 500 mg/kg) were found in the Acid Plant Water Treatment Facility at wells DH-19 and ASPD-14. Cadmium values above 100 mg/kg were found at various locations on the plant site including the area between Upper Lake and Lower Lake, the ore storage yard (SC-4 and SC-3), the Speiss Pit area (DH-28) and in one sample from DH-10 on the northern edge of the slag pile.

Lead concentrations in subsurface soils range from less than 10 mg/kg to 197,000 mg/kg (Exhibit 4-1-3). The areas of high concentration are generally similar to arsenic and cadmium. Lead is also high at locations where slag is present. Lead concentrations in excess of 10,000 mg/kg were detected at various locations on the southern half of the plant site including:

- The former acid plant sediment drying areas (ASPD-14 and DH-29),
- In DH-19 near the former acid plant water treatment facility,
- In fill material in the former upper ore storage area between Upper and Lower Lake,
- At sites where slag is present (DH-4, DH-5 and DH-23), and
- In shallow fill material at DH-27.

The highest arsenic and metal concentrations are associated with previously identified source areas on the southern half of the plant site.

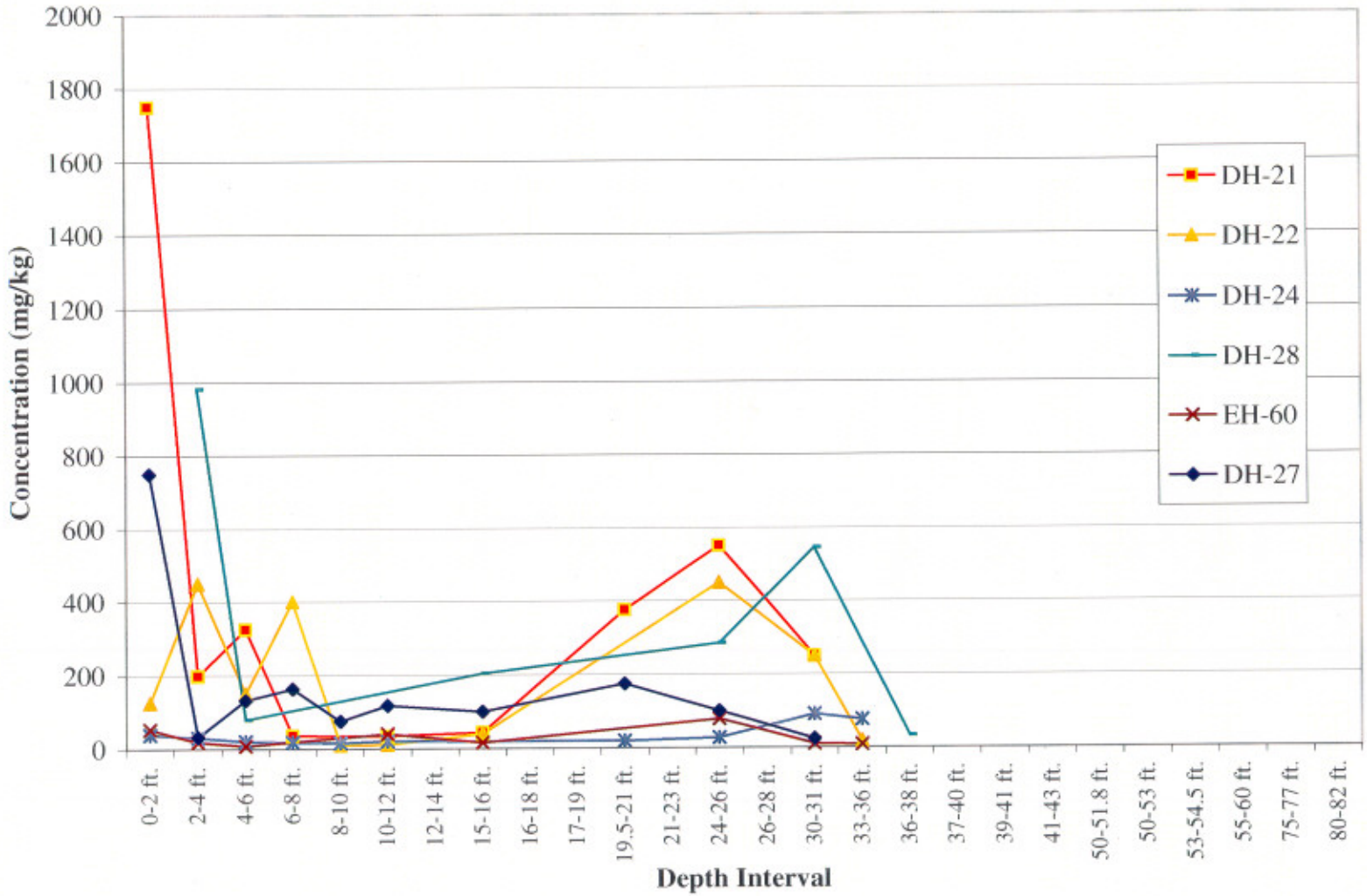


FIGURE 4-1-2. SOIL ARSENIC CONCENTRATIONS VERSUS DEPTH AT SELECTED PLANT SITE MONITORING WELL LOCATIONS

4.1.2.2 Post-RI Subsurface Sample Data

Since the RI, additional subsurface soil characterization was conducted as part of implementation of remedial measures in accordance with the Process Ponds ROD. The results of these additional investigations are described below:

Lower Lake

The Record of Decision (ROD), issued by the Environmental Protection Agency (EPA) in November 1989, required the removal of all process sludge plus 24 inches of underlying marsh deposits from Lower Lake. The Explanation of Significant Differences (ESD), issued by the EPA on June 17, 1993, modified the ROD removal requirements by reducing the removal depth of underlying marsh deposits from 24 inches to six inches. The ESD was based on an examination of the decrease of arsenic and metals in the marsh deposits with increasing depth (Hydrometrics, 1993). The ESD explained:

> ". . . core samples were taken and leachability tests were conducted for each layer, as well as for the two layers together. The additional tests demonstrated that the sludge layer, despite being delisted, exhibits characteristics of a hazardous waste. The results also indicated that the underlying marsh sediments were not the source of contamination that they were originally thought to be; in fact, the tests concluded that by excavating only six inches of marsh sediments instead of two feet of marsh sediments, the remedy would be protective of human health and the environment."

Beginning in 1994 and concluding in 1996, process sludge and the top 6-inches of the marsh deposits (collectively referred to as Lower Lake sediments) were dredged from the lake. The dredged sediments were mechanically dewatered and the filter cake from the dewatering operation was transported to an interim covered stockpile in the Lower Ore Storage Area. Approximately 31,000 cubic yards of dewatered Lower Lake sediments were transported to the Lower Ore Storage Area. Four thousand cubic yards of these sediments were smelted

prior to the remainder of stockpile being covered with a geomembrane liner in October 1997. The sediments were covered in accordance with the plan for a Short Term Storage Facility for Lower Lake Process Sludge and Marsh Deposits (Hydrometrics, 1997d). The sediments will remain in this interim storage facility while EPA considers Asarco's request to modify the sediment smelting requirement of the ROD, and instead dispose of these materials in a proposed on-site CAMU.

As part of Lower Lake remedial design and remediation activities, an extensive core sampling and subsequent analysis program was conducted in April and June, 1995 (Hydrometrics, 1995). Results of this program provide a comprehensive assessment of the sediments dredged from Lower Lake as well as characterize the marsh deposits remaining in the lake.

- In April and June of 1995, sediment core samples were collected at 42 sites in Lower Lake for laboratory analysis of arsenic, copper, cadmium, lead and zinc. Soil samples were composited in 6 inch intervals and submitted for XRF analysis. The soil core lithology was logged in the field as process sludge, top of the marsh deposits and marsh deposits. These distinctions were used for the summary statistics presented in Table 4-1-4. The purpose of the sampling program was to determine as accurately as possible, the elevation of the interface between the process sludge and the underlying marsh deposits, since the interface was the "benchmark" from which the required dredging was determined. Since the "benchmark" for setting the Lower Lake sediments removal target was the top of the marsh deposits, lithological descriptions alone should have provided sufficient data to determine this interface. However, XRF analyses were also conducted to provide additional assurance that the process sludge/marsh deposits interface was accurately located, especially in areas where there were no distinct sand layers to uniquely characterized the marsh deposits. In this regard, lithological descriptions and XRF analysis (total arsenic and metals) were compared for each of the analyzed cores to verify the correlation between lithologic descriptions and

TABLE 4-1-4: STATISTICAL SUMMARY OF LOWER LAKE SOIL CORE DATA

Interval 1 (Process Sludge)	Total Arsenic (mg/Kg)	Total Cadmium (mg/Kg)	Total Copper (mg/Kg)	Total Lead (mg/Kg)	Total Zinc (mg/Kg)
Geometric Mean	13249	2258	6352	30620	19585
Average	16582	2994	7421	34128	21478
Median	13694	2522	6594	32800	18790
Minimum	2532	452	2131	11891	6877
Maximum	40860	15524	16144	70170	42592
Standard Deviation	10178	3049	4123	15855	9372
Count	21	21	21	21	21
Interval 2 (Top of Marsh to 6 inches)					
Geometric Mean	1879	263	1143	6018	5840
Average	2130	306	1378	7193	6399
Median	1865	254	1091	6146	5759
Minimum	665	54	240	1457	1769
Maximum	6924	758	3753	18017	11248
Standard Deviation	1285	174	870	4240	2665
Count	21	21	21	21	21
Interval 3 (6 to 12 inches)					
Geometric Mean	1040	52	675	2923	3443
Average	1513	215	945	5006	4189
Median	930	109	568	2191	2796
Minimum	188	3	93	541	721
Maximum	10668	2077	4728	37422	11661
Standard Deviation	1812	388	961	6896	2876
Count	41	41	41	41	41
Interval 4 (12 to 18 inches)					
Geometric Mean	784	128	595	2416	3085
Average	1882	624	1146	6485	4228
Median	707	103	495	1852	2906
Minimum	126	15	75	407	590
Maximum	11540	8269	5671	37380	16750
Standard Deviation	3071	1827	1625	11189	3946
Count	20	20	20	20	20
Interval 5 (18 to 36 inches)					
Geometric Mean	260	31	409	1071	2052
Average	1171	106	973	4714	2969
Median	113	13	240	666	1674
Minimum	77	8	91	292	972
Maximum	6917	480	4644	28069	10793
Standard Deviation	2544	177	1641	10323	3507
Count	7	7	7	7	7

arsenic and metals concentrations in the process sludge and marsh deposits. In addition, ten split samples were analyzed at Asarco's TSC-SLC laboratories for the same parameters. An excellent correlation between XRF and wet chemistry methods were obtained.

XRF analysis of the cores found that total arsenic and metals values dropped off immediately and significantly as materials containing sand and/or mica, which uniquely characterized the presence of marsh deposits, were encountered. In addition, areas which had been dredged in 1994 and did not contain any of the material determined to be process sludge, showed relatively low total metals levels. These areas, which contained no process sludge and had relatively low metal values (i.e., metal values comparable to those found more than six inches below the interface in areas not dredged), were determined to have met the project removal targets. In some areas, it was difficult to determine the top of the marsh deposits because the cores consisted mostly of clay and little or no sand or mica. In these areas, XRF data were compared to XRF data for other areas of the lake where the top of the marsh deposits was clearly evident from the lithological logs to determine removal requirements.

Other Lower Lake sediment core samples were also collected at various times as part of the Lower Lake remediation. The extent of each of these sample collections was more limited than the 1995 effort and, typically, the samples were subjected to various leaching methods instead of total constituents by XRF. Results of these other analyses were, however, consistent with analytical results for the 1995 samples, in that, all results show substantial arsenic and metals were present in the process sludge, but decline rapidly once in the marsh deposits were encountered. Since a detailed discussion of the results of these other sampling efforts would not substantively contribute to a better understanding of the marsh deposits still in Lower Lake, that discussion is not included in this document. However, for purposes of

including all the available information on Lower Lake sediment, all of the data are included in Appendix and the supplemental sampling events are outlined below.

- In October 1991, core samples were collected at eight sites. TCLP tests were conducted on these core samples.
- Additional core samples were gathered in April and May 1992 from nine sites. EPTOX and TCLP tests were conducted on these core samples and the leachate was analyzed for total arsenic and metals. During the April and May 1992 sampling period, three additional core samples of Lower Lake bottom sediments were collected; one from a previously unsampled site and two from sites originally sampled in October, 1991. These three samples were also analyzed for total arsenic and metals.
- In August of 1992, seven sites from the April and May 1992 sampling event were re-sampled and the leachate from EPA Method 1312 and EPTOX were analyzed for total arsenic and metals.
- In June 1992, one treatment sludge sample was collected from the in-situ pilot scale treatment area. This sample was analyzed for total arsenic and metals.
- In October 1992, five core samples were taken at six inch intervals (from 8.5 ft. to 11.0 ft. below the water surface) from site LH-34 which had been previously sampled in August 1992. These samples were analyzed for total arsenic and metals.

Former Thornock Lake

Former Thornock Lake was an unlined process pond used to contain plant water and storm water runoff prior to 1987. Thornock Lake was replaced with a steel tank within a concrete vault during 1986 and 1987. Prior to placement of the tank, a portion of the sediments in the former pond area were removed to a depth of five feet. At this depth, test results from the underlying coarse sediments showed that arsenic and metal concentrations were near background level (refer to Table 4-1-5, sites TH-1 and TH-2). The excavated area was

TABLE 4-1-5: FORMER THORNOCK LAKE SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM AND LEAD

Sample Site	Sample Date	Sample Depth[1]	Material	Total Metals (mg/Kg)			EP Tox (mg/L)[2]			SPLP (mg/L)[2][4]		
				As	Cd	Pb	As	Cd	Pb	As	Cd	Pb
TH-1	12/18/87	1-2 ft.	----	34950	16525	17325	----	----	----	----	----	----
	12/18/87	2-3 ft.	----	43900	35000	21075	----	----	----	----	----	----
	12/18/87	3-4 ft.	----	120375	106950	21875	----	----	----	----	----	----
	12/18/87	4-5 ft.	----	52	0.75	6.8	----	----	----	----	----	----
TH-2	12/18/87	0.5-2 ft.	----	691	242	8935	----	----	----	----	----	----
	12/18/87	2-4 ft.	----	44	3.8	221	----	----	----	----	----	----
	12/18/87	6-8 ft.	----	22	3.4	170	----	----	----	----	----	----
	12/18/87	8-10 ft.	----	53	1.9	14	----	----	----	----	----	----
	12/18/87	10-12 ft.	----	191	5.5	64	----	----	----	----	----	----
	12/18/87	15-17 ft.	----	164	3	28	----	----	----	----	----	----
	12/18/87	20-21 ft.	----	52	1.5	24	----	----	----	----	----	----
	12/18/87	25-27 ft.	----	21	1.5	41	----	----	----	----	----	----
TL-3	6/24/91	0-4 inches	Fine-grained sediments	45000	33175	158500	193	133	0.6	----	----	----
	6/24/91	4-12 inches	Fine-grained sediments	43900	23225	95000	58.5	31.3	0.3	----	----	----
	6/24/91	1-2 ft.	Fine-grained sediments	36254	15725	64000	118	58.2	1.6	----	----	----
	6/24/91	2-3 ft.	Fine-grained sediments	455	22	2183	0.2	<0.1	0.3	----	----	----
	6/24/91	3-4 ft.	Alluvium	1458	11	230	9.5	<0.1	<0.1	----	----	----
	6/24/91	4-5 ft.	Alluvium	580	14	353	6	0.1	<0.1	----	----	----
TL-4	6/24/91	0-4 inches	Fine-grained sediments	4375	2378	8875	13	16	0.5	----	----	----
	6/24/91	4-12 inches	Fine-grained sediments	550	270	990	3.2	0.6	<0.1	----	----	----
	6/24/91	1-2 ft.	Fine-grained sediments	940	458	990	1.9	0.2	<0.1	----	----	----
	6/24/91	2-3 ft.	Fine-grained sediments	375	127	61	4.8	0.3	<0.1	----	----	----
	6/24/91	3-4 ft.	Fine-grained sediments	310	105	64	4.7	0.2	<0.1	----	----	----
	6/24/91	4'-4.5'	Alluvium	535	154	66	3.6	0.1	<0.1	----	----	----
TL-001	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	1163	135	328	2.8	0.15	<0.1	1.4	0.01	<.1
TL-002	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	1788	493	5250	2.0	1.9	<0.1	0.63	0.31	<.1
TL-003	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	1053	235	1225	2.0	0.78	<0.1	1.6	0.05	<.1
TL-004	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	853	23	453	2.2	0.02	<0.1	2.0	<.01	<.1
TL-005	12/10/91	+ 1 ft.	Slag/Sludge sample (above grade)	3055	510	14,500	0.93	1.3	0.8	1.2	<.01	<.1
TL-006	12/10/91	0	F. gr. sludge intermixed with slag pieces (to 6" dia.)	750	2.2	98	0.23	<.01	<0.1	0.22	<.01	<.1
TL-007	12/10/91	1-2 ft.	F. gr. sludge intermixed with slag pieces (to 6" dia.)	513	0.91	33	<.1	<.01	<0.1	0.32	<.01	<.1
TL-008	12/10/91	2-3 ft.	Sandy, clayey, silt vermuculte, pyrite present	1400	27	55	2.6	<.01	<0.1	3.8	<.01	<.1
TL-009	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	678	28	130	1.8	<.01	<0.1	2.2	<.01	<.1

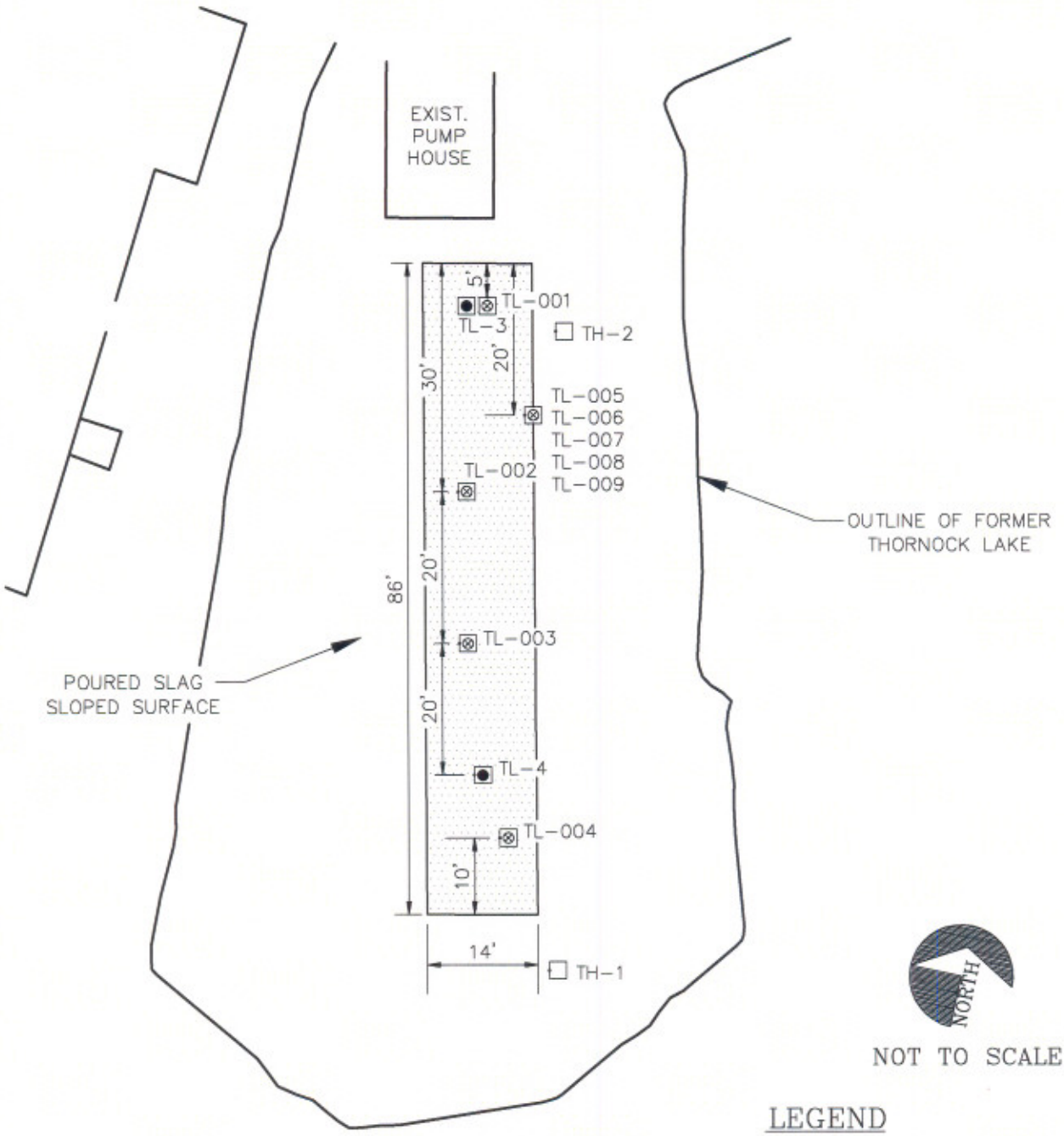
Notes: (1) Measured from top of natural sediment - i.e., initial pond bottom elevation.
(2) EPToxicity Limits: As=5 mg/L, Cd = 0.5 mg/L, Pb = 5 mg/L
(3) SPLP - Synthetic Precipitation Leach Procedure

backfilled with clean fill to facilitate placement of the new tank and vault. Sediments excavated from Former Thornock Lake were smelted.

The 1989 Process Ponds ROD required that the remaining sediments be removed from former Thornock Lake. The depth of excavation was determined by EP toxicity testing of the sediments. In June 1991 twelve pre-excavation soil samples from Former Thornock Lake were collected from two test pits (TL-3 and TL-4), at each end of the former pond area (see Figure 4-1-3). Soil samples were collected at approximately one-foot intervals to a total depth of 4.5 feet at TL-3 and to 5 feet at TL-4. Laboratory analyses of these samples showed that the majority of the metals and arsenic were contained in fine-grained sediments that had accumulated within the former process pond (Table 4-1-5).

The Thornock Lake bottom sediments generally consisted of fine-grained, plastic, organic clay with elevated concentrations of arsenic and metals. Beneath these fine-grained sediments were coarser-grained sand, gravel and cobbles. Based on the analytical results, it was determined that slag, remaining fine-grained sediment, and 3.5 to 4 feet of the underlying coarse-grained sediment would be removed from the former pond area. Excavation was conducted in accordance with the work plan submitted to EPA on October 22, 1991 (see Remedial Action Report, Hydrometrics 1992) and under oversight provided by EPA. Approximately 185 cubic yards of slag were excavated and placed on the smelter slag pile. An additional 407 cubic yards of fine-grained sediment and alluvium were excavated and stockpiled in the Lower Ore Storage Area and subsequently smelted. The excavation area is shown on Figure 4-1-3 and Exhibit 4-1-1.

In December 1991, four soil samples (TL-001 through TL-004) were collected from the bottom of the completed excavation. Five additional samples were collected in one-foot intervals vertically at a single location along the north wall of the excavation (TL-005 through TL-009). These soil samples were submitted for analysis of total arsenic and selected metals, EP Toxicity testing, and synthetic precipitation leaching procedure testing (SPLP). Laboratory results (see Table 4-1-5) indicate arsenic and lead concentrations for all



NOT TO SCALE

LEGEND

□ TH-1	PRE-EXCAVATION SOIL SAMPLE LOCATION. (DECEMBER 1987)
◉ TL-4	PRE-EXCAVATION SOIL SAMPLE LOCATION. (JUNE 1991)
⊗ TL-004	POST-EXCAVATION SOIL SAMPLE LOCATION. (DECEMBER 1991)

NOTE:
TH-1 & TH-2 LOCATION IS APPROXIMATE.

ASARCO INCORPORATED
CC/RA EAST HELENA FACILITY

THORNOCK LAKE SOIL EXCAVATION AND SAMPLING LOCATIONS

FIGURE
4-1-3

UPDATE TIME: 3:13PM
007\0867\065\0127\HEL\011299\I:\STORAGE\86799a14.dwg

post-excavation samples were below EP Toxicity limits with the exception of one sample (TL-002) which exceeded EP toxicity limits for cadmium. Remedial activities for Thornock Lake are described in additional detail in Hydrometrics May 1992 report, titled "Excavation of Bottom Sediments from Former Thornock Lake."

Speiss Pond and Speiss Pit Area

The speiss settling pond (the "Speiss Pond") and speiss granulating pit (the "Speiss Pit") were formerly located immediately to the north of the dross plant. Until 1991, the Speiss Pond and Speiss Pit were used to store water for use in the speiss granulation process. Speiss, a molten copper bearing material, was granulated by spraying it with water in the Speiss Pit. The water then drained to the Speiss Pond to be recirculated during the next granulating cycle. In 1991, Asarco switched to an air granulation process, which used only a light water mist, thus eliminating the need for a speiss process water circuit.

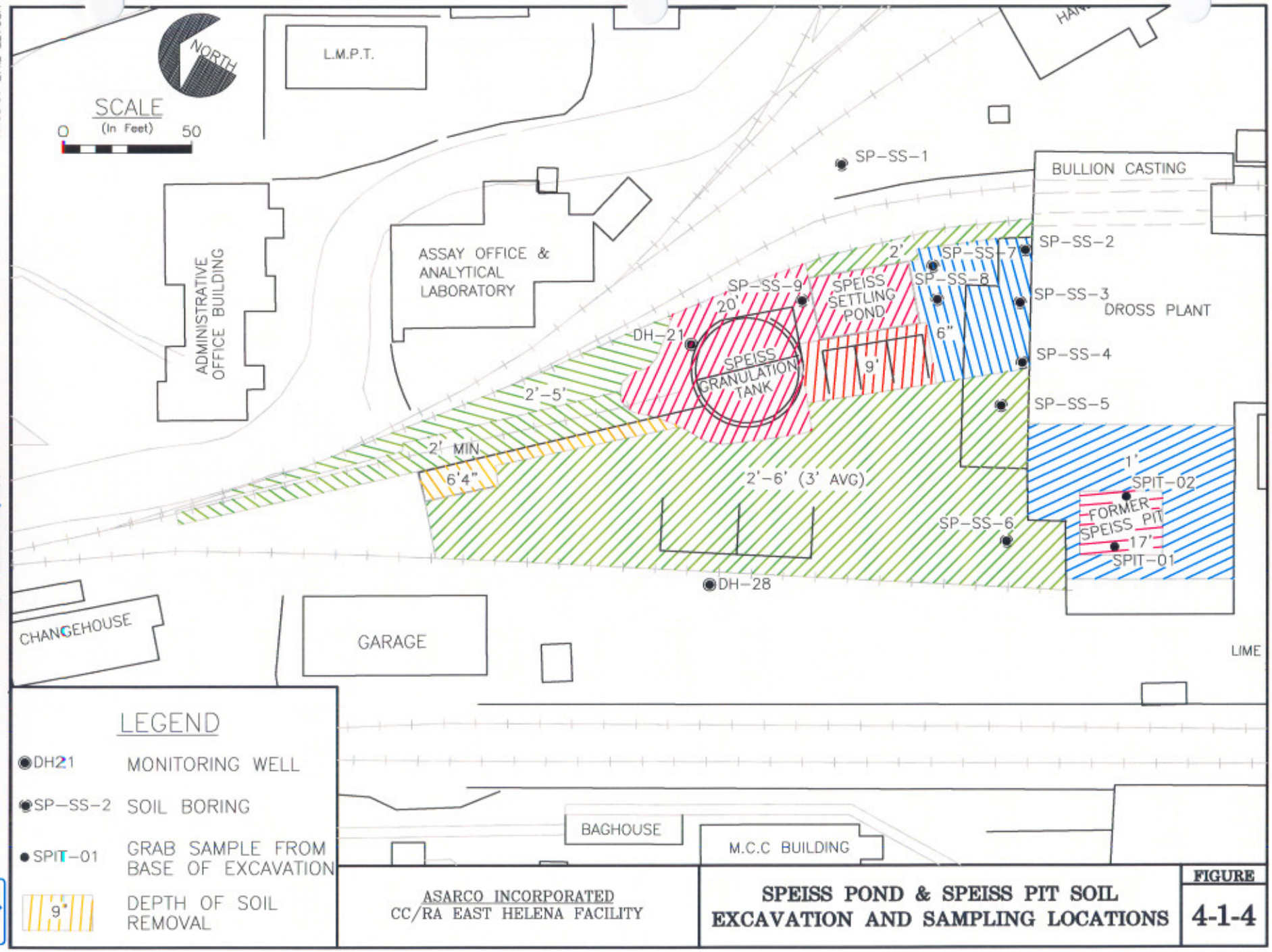
The Speiss Pond and Speiss Pit were identified early in the RI/FS process as potential sources of process water seepage to groundwater. Remediation of the Speiss Pond and Speiss Pit area was initiated in 1988 with the HDPE lining of the Speiss Pond. Later in 1988, a portion of the original Speiss Pond was removed and replaced with a tank (the "Speiss Tank") with leak detection and secondary containment. Soils were also excavated in the surrounding area as part of grading and storm water improvements. A total of 2500 cubic yards of soil were excavated during this phase of remediation. During these initial speiss pond excavation activities, oversite was provided by EPA. The remaining portion of the Speiss Pond was removed in 1992 in accordance with the Process Pond ROD, and the Final Design Report for Sediment and Soil Excavation and Smelting (Hydrometrics 1991b). During excavation in 1992, an additional 235 cubic yards of soil were removed as EPA provided oversight (Hydrometrics 1992b). Soil was excavated to a depth of approximately 20 feet beneath the original Speiss Pond structure. Excavated Soils were subsequently stored in the Lower Ore Storage area (see Section 4.1.3 below).

The Speiss Pit was removed and replaced with a new pit in 1995 during construction of the new dross-reverberatory building. In accordance with the Process Pond ROD, and the Final Design Report for Sediment and Soil Excavation and Smelting (Hydrometrics 1991b), a total of 250 cubic yards of soil were removed to a depth of 17 feet beneath the original Speiss Pit. During excavation of the speiss pit in 1995, oversight was provided by EPA. Subsequent to excavation, the soils were stored in the Lower Ore Storage Area (see Section 4.1.3 below). The depth and lateral extent of soil excavation in the Speiss Pond and Speiss Pit area are shown in Figure 4-1-4 and Exhibit 4-1-1.

No soil sample results were recorded for the Speiss Pond demolition phase since remediation objectives were depth-based, but pre-excavation soil samples were collected at soil borings and monitoring wells and show the general distribution of metals in subsurface soils. Soils data are available from two monitoring wells (DH-21 and DH-28) and nine soil borings (SS-1 through SS-9). Two post excavation samples (SPIT-01 and SPIT-02) were also collected at the former Speiss Pit. Soil sample locations in the Speiss Pond and Speiss Pit area are shown in Figure 4-1-4. Soils from the monitoring well DH-21 and from the Speiss Pit excavation were analyzed for total arsenic and EP Toxicity testing was also conducted on soils from DH-21 and from the nine borings in the Speiss Pond area. Pre and post-excavation soils data are summarized in Table 4-1-6. Sequential extraction analyses were also run on soils from monitoring well DH-21, adjacent to the Speiss Pond excavation. The data are included in Appendix 3-1-3.

Acid Plant Water Treatment Facility

Prior to 1992, suspended sediments from the acid scrubbing process were settled in a concrete lined settling pond and in-line settling tubs (dumpsters), and neutralized by lime application at the former acid reclaim facility. This system was identified in the RI as a source of process water seepage to groundwater. A new Acid Plant Water Reclaim Facility was completed in November 1992 and the original settling pond was subsequently demolished beginning in February 1993.



UPDATE TIME: 10:50AM
007\0867\065\0127\HEL\011899\I:\STORAGE\86799a15.dwg

Hydrometrics, Inc. Consulting Scientists, Engineers and Contractors

TABLE 4-1-6: SPEISS POND AND SPEISS PIT SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM & LEAD

Arsenic	EP Toxicity As (mg/L)										Total As (mg/Kg)			
DATE	7/25/89	7/25/89	7/25/89	7/26/89	7/26/89	7/28/89	7/28/89	7/28/89	7/28/89	4/23/87	4/23/87	12/11/87	7/24/95	7/24/95
DEPTH \ *SITE*	*SP-SS-1*	*SP-SS-2*	*SP-SS-3*	*SP-SS-4*	*SP-SS-5*	*SP-SS-6*	*SP-SS-7*	*SP-SS-8*	*SP-SS-9*	*DH-21*	*DH-21*	*DH-28*	*SPIT-01*	*SPIT-02*
surface	----	----	----	----	----	----	----	----	----	----	----	----	----	----
0-2 ft.	1.5	0.55	7.5	4.6	1	0.97	<0.2	0.49	0.82	1.5	1750	----	----	----
1-3 ft.	----	----	----	----	----	----	----	----	----		----	749	----	----
2-4 ft.	0.21	0.71	6.4	2.4	<0.2	0.23	0.27	0.2	1	0.91	198	983	----	----
4-6 ft.	<0.2	2.7	4.9	4.2	<0.2	<0.2	<0.2	0.2	<0.2	----	325	79	----	----
6-8 ft.	0.24	0.56	0.39	4.5	<0.2	<0.2	<0.2	0.2	3.4	0.025	36	----	----	----
8-10 ft.	2.3	<0.2	0.93	<0.2	0.69	<0.2	0.23	<0.2	2.9	----	----	----	----	----
10-12 ft.	0.67	0.26	0.28	1.6	0.38	<0.2	<0.2	<0.2	0.45	0.011	34	----	----	----
12-14 ft.	2.3	1.1	0.51	0.57	0.29	<0.2	0.91	<0.2	0.23	----	----	----	----	----
14-16 ft.	3.6	0.31	0.23	1.3	0.26	<0.2	<0.2	<0.2	4.9	----	43	204	----	----
16-18 ft.	<0.2	0.27	<0.2	0.64	0.25	<0.2	<0.2	<0.2	5.8	----	----	----	----	----
18-20 ft.	----	0.96	<0.2	1.7	----	<0.2	0.63	----	2.4	----	----	----	----	----
20-21 ft.	----	----	----	----	----	----	----	----	----	----	375	----	723	1425
24-26 ft.	----	----	----	----	----	----	----	----	----	----	550	285	----	----
30-31 ft.	----	----	----	----	----	----	----	----	----	----	250	545	----	----
36-38 ft.	----	----	----	----	----	----	----	----	----	----	----	32	----	----

Cadmium	EP Toxicity Cd (mg/L)										Total Cd (mg/Kg)			
DEPTH \ *SITE*	*SP-SS-1*	*SP-SS-2*	*SP-SS-3*	*SP-SS-4*	*SP-SS-5*	*SP-SS-6*	*SP-SS-7*	*SP-SS-8*	*SP-SS-9*	*DH-21*	*DH-21*	*DH-28*	*SPIT-01*	*SPIT-02*
surface	----	----	----	----	----	----	----	----	----	----	----	----	----	----
0-2 ft.	0.21	0.1	1.1	0.09	1.6	0.07	1.5	2.5	1.3	0.88	90	----	----	----
1-3 ft.	----	----	----	----	----	----	----	----	----	----	----	306	----	----
2-4 ft.	<0.05	<0.05	0.55	0.35	2.2	0.06	1.9	2	0.22	0.16	5.5	200	----	----
4-6 ft.	<0.05	0.22	0.41	<0.05	0.1	<0.05	<0.05	0.38	<0.05	----	4.5	1.1	----	----
6-8 ft.	<0.05	0.07	<0.05	0.06	0.08	<0.05	<0.05	0.1	<0.05	0.003	6	----	----	----
8-10 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	----	----	----	----	----
10-12 ft.	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.001	<0.5	----	----	----
12-14 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	----	----	----	----	----
14-16 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	----	<0.5	1.2	----	----
16-18 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	----	----	----	----	----
18-20 ft.	----	<0.05	<0.05	<0.05	----	<0.05	<0.05	----	<0.05	----	----	----	----	----
20-21 ft.	----	----	----	----	----	----	----	----	----	----	1.5	----	<10	<10
24-26 ft.	----	----	----	----	----	----	----	----	----	----	1	27	----	----
30-31 ft.	----	----	----	----	----	----	----	----	----	----	4.5	352	----	----
36-38 ft.	----	----	----	----	----	----	----	----	----	----	----	9.8	----	----

Lead	EP Toxicity Pb (mg/L)										Total Pb (mg/Kg)			
DEPTH \ *SITE*	*SP-SS-1*	*SP-SS-2*	*SP-SS-3*	*SP-SS-4*	*SP-SS-5*	*SP-SS-6*	*SP-SS-7*	*SP-SS-8*	*SP-SS-9*	*DH-21*	*DH-21*	*DH-28*	*SPIT-01*	*SPIT-02*
surface	----	----	----	----	----	----	----	----	----	----	----	----	----	----
0-2 ft.	0.15	0.74	5.4	0.3	25	0.3	18	58	7.1	29	5500	----	----	----
1-3 ft.	----	----	----	----	----	----	----	----	----	----	----	2600	----	----
2-4 ft.	<0.1	0.19	3.1	0.79	16	0.84	17	33	2.1	1.4	170	8535	----	----
4-6 ft.	<0.1	2.1	2.9	<0.1	0.18	<0.1	0.23	3.1	<0.1	----	185	22	----	----
6-8 ft.	<0.1	0.28	0.54	<0.1	0.34	<0.1	<0.1	0.41	<0.1	<0.013	21	----	----	----
8-10 ft.	<0.1	0.12	1.8	<0.1	<0.1	<0.1	<0.1	0.14	<0.1	----	----	----	----	----
10-12 ft.	<0.1	<0.1	0.56	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.013	11	----	----	----
12-14 ft.	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	----	----	----	----	----
14-16 ft.	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	----	12	20	----	----
16-18 ft.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	----	----	----	----	----
18-20 ft.	----	<0.1	<0.1	<0.1	----	<0.1	<0.1	----	<0.1	----	----	----	----	----
20-21 ft.	----	----	----	----	----	----	----	----	----	----	38	----	919	4520
24-26 ft.	----	----	----	----	----	----	----	----	----	----	14	24	----	----
30-31 ft.	----	----	----	----	----	----	----	----	----	----	94	18	----	----
36-38 ft.	----	----	----	----	----	----	----	----	----	----	----	28	----	----

Notes: EPToxicity Limits: As=5 mg/L, Cd = 0.5 mg/L, Pb = 5 mg/L

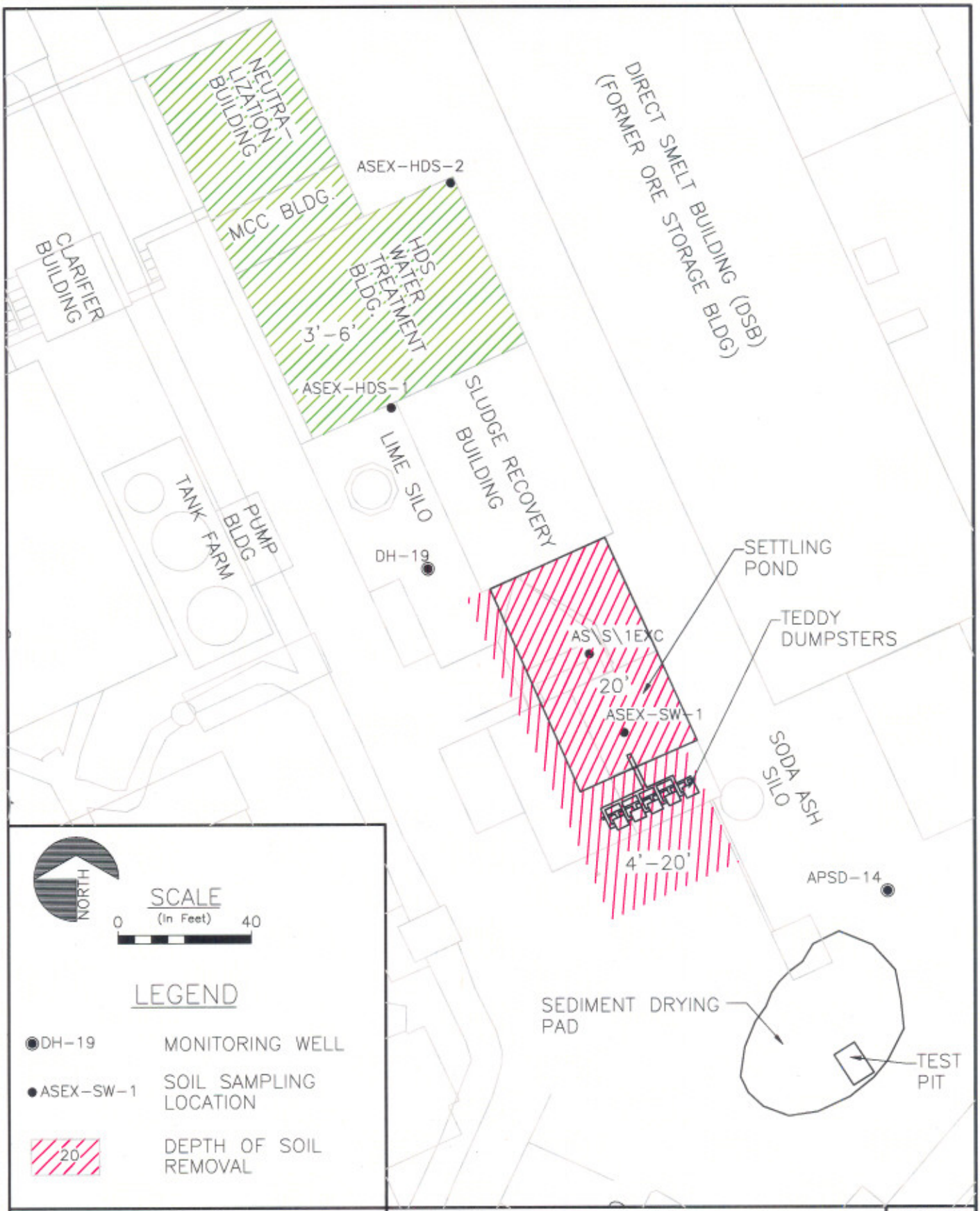
In accordance with the Process Pond ROD and the Final Design Report for Sediment and Soil Excavation and Smelting (Hydrometrics 1991b), soil was excavated to a maximum depth of approximately 20 feet at the settling pond (Hydrometrics 1992b). Because the soils were partially cemented or indurated beneath the settling pond, the excavation could be advanced 8 to 11 feet below the water table. A total of 2200 cubic yards of soil was excavated from beneath the settling pond. Soils were also excavated and sampled in the area north of the settling pond during construction of the HDS Water Treatment Facility. Figure 4-1-5 shows the limits and depth of excavations in the vicinity of the acid plant treatment facility. Excavated soils were subsequently stored in the Lower Ore Storage Area (see Section 4.1.3, below).

One pre-excavation soil sample was taken on April 1, 1993 following removal of the settling pond's concrete walls and floor (ASEX-SW-1). Excavation of soils underlying the former pond was completed on April 28, 1993. One post-excavation soil sample was taken from the settling pond excavated soil pile (AS\S\1EXC) and two samples were collected from the base of the excavation at the HDS building site (ASEX-HDS-1 and HDS-2). Soil sample locations are shown in Figure 4-1-5. These soils were analyzed for total arsenic and selected metals, and EP Toxicity.

Pre- and post-excavation sample results are summarized in Table 4-1-7. Soils data were also collected at monitoring well DH-19 immediately downgradient of the settling pond. The soil samples from DH-19 were analyzed for total arsenic and metals. Sequential extraction analyses were also run on selected samples. These data are included in the soil quality data base in Appendix 3-1-3.

Acid Plant Sediment Drying Areas

From 1977 through 1991, sludge from the Acid Plant Water Treatment Facility was stored on the Acid Plant Sediment Drying (APSD) Pad between Upper Lake and Lower Lake. In July



ASARCO INCORPORATED
CC/RA EAST HELENA FACILITY

SOIL EXCAVATION DEPTHS AT ACID PLANT WATER TREATMENT FACILITY

FIGURE
4-1-5

UPDATE TIME: 1:04PM
007\0867\065\0127\HEL\011899\I:\STORAGE\86799a16.dwg

Hydrometrics, Inc. Consulting Scientists, Engineers and Contractors

TABLE 4-1-7: ACID PLANT WATER TREATMENT FACILITY SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM & LEAD

Arsenic	TCLP As (mg/L)	EP TOX As (mg/L)	Total As (mg/Kg)				
DATE	5/17/93	4/22/87	4/22/87	4/8/93	4/8/93	4/1/93	5/17/93
DEPTH \ *SITE*	*AS\S\IEXC*	*DH-19*	*DH-19*	*ASEX-HDS-1*	*ASEX-HDS-2*	*ASEX-SW-1*	*AS\S\IEXC*
surface	----	----	----	----	----	----	----
0-2 ft.	----	0.22	2400	----	----	----	----
2-4 ft.	----	0.68	950	----	----	----	----
4-6 ft.	----	0.29	650	9591	53	----	----
6-8 ft.	----	3.5	11100	----	----	2346	----
8-10 ft.	----	12000	12000	----	----	----	----
10-12 ft.	----	10	2750	----	----	----	----
14-16 ft.	----	5.1	850	----	----	----	----
20-22 ft.	0.33	----	225	----	----	----	8548
24-26 ft.	----	0.06	175	----	----	----	----

Cadmium	TCLP Cd (mg/L)	EP TOX Cd (mg/L)	Total Cd (mg/Kg)				
DEPTH \ *SITE*	*AS\S\IEXC*	*DH-19*	*DH-19*	*ASEX-HDS-1*	*ASEX-HDS-2*	*ASEX-SW-1*	*AS\S\IEXC*
surface	----	----	----	----	----	----	----
0-2 ft.	----	10	480	----	----	----	----
2-4 ft.	----	6	285	----	----	----	----
4-6 ft.	----	2.7	50	305	7	----	----
6-8 ft.	----	2	690	----	----	138	----
8-10 ft.	----	425	425	----	----	----	----
10-12 ft.	----	1.2	180	----	----	----	----
14-16 ft.	----	0.37	140	----	----	----	----
20-22 ft.	6.3	230	230	----	----	----	884
24-26 ft.	----	1	120	----	----	----	----

Lead	TCLP Pb (mg/L)	EP TOX Pb (mg/L)	Total Pb (mg/Kg)				
DEPTH \ *SITE*	*AS\S\IEXC*	*DH-19*	*DH-19*	*ASEX-HDS-1*	*ASEX-HDS-2*	*ASEX-SW-1*	*AS\S\IEXC*
surface	----	----	----			----	----
0-2 ft.	----	49	14250	----	----	----	----
2-4 ft.	----	39	12000	----	----	----	----
4-6 ft.	----	0.22	600	13347	455	----	----
6-8 ft.	----	0.088	2600	----	----	3741	----
8-10 ft.	----	800	800	----	----	----	----
10-12 ft.	----	0.013	135	----	----	----	----
14-16 ft.	----	0.013	155	----	----	----	----
20-22 ft.	8.4	115	115	----	----	----	44325
24-26 ft.	----	0.0065	34	----	----	----	----

Notes: EP Toxicity Characteristic Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L
Toxicity Characteristic Leaching Procedure (TCLP) Regulatory Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L

of 1991, the use of Acid Plant sludge was permanently discontinued. The dried Acid Plant sludge was subsequently smelted.

Subsurface soils data have been collected from the following sites in the Acid Plant Sediment Drying area adjacent to Lower Lake:

- Monitoring well (DH-29) was drilled on the northwest side of the pad during RI activities. Soil samples were collected to a depth of 19 feet and analyzed for total arsenic and metals.
- In August of 1991, four post-RI monitoring wells (ASPD-1 through ASPD-4) were installed at sites in and adjacent to the former sediment drying area (see Exhibit 4-1-1). Drill hole soil samples were taken at two-foot intervals and analyzed for arsenic and metals using the EP Toxicity test procedure.
- In response to an EPA informational request (See Appendix 3-1-1), additional borehole samples (1-7 ft. composites) were taken at nine (9) sites in the sediment drying pad area (APSD-P1 through P4, P6, P8 and P9) in August and September of 1996. These samples were analyzed for total arsenic and metals, TCLP and synthetic precipitation leaching procedure tests (SPLP).

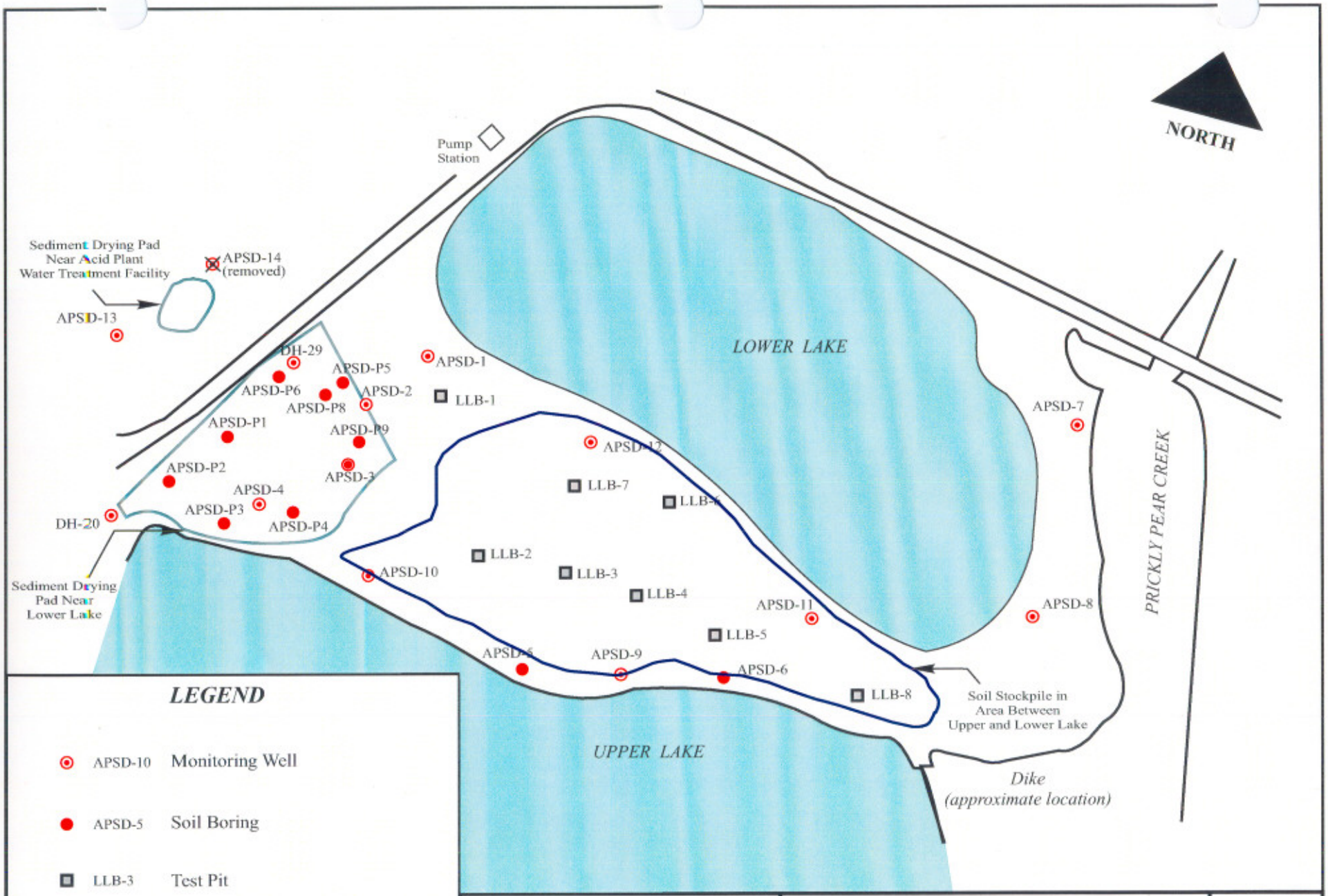
Table 4-1-8 summarizes subsurface soil data for the APSD Pad.

A second smaller sediment drying pad (0.04 acres) was located nearer to the former acid plant water treatment facility (Figure 4-1-6). APSD-13 and APSD-14 were installed nearby to evaluate soil quality. Soil samples were collected at 2 ft intervals to depths of 23 feet at APSD-13 and 16 feet at APSD-14. Soils were analyzed for total and TCLP arsenic and metals. Analytical results are summarized in Table 4-1-8. In accordance with the Process Pond ROD and the Final Design Report for Sediment and Soil Excavation and Smelting (Hydrometrics 1991 b) sediments from the small sediment drying area adjacent to the former acid plant water treatment facility (see Figure 4-1-6) were excavated. The sediments were subsequently transported to the Lower Ore Storage area for storage (see Figure 4-1-7).

TABLE 4-1-8: ACID PLANT SEDIMENT DRYING AREA SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM & LEAD

Arsenic	EP TOX As (mg/L)				TCLP As (mg/L)							Total As (mg/Kg)							
DATE	8/20/91	8/20/91	8/21/91	8/21/91	8/16/96	8/16/96	8/16/96	8/16/96	8/16/96	9/20/96	9/20/96	12/11/87	8/16/96	8/16/96	8/16/96	8/16/96	8/16/96	9/20/96	9/20/96
DEPTH \ *SITE*	*APSD-1*	*APSD-2*	*APSD-3*	*APSD-4*	*APSD-P1*	*APSD-P2*	*APSD-P3*	*APSD-P4*	*APSD-P6*	*APSD-P8*	*APSD-P9*	*DH-29*	*APSD-P1*	*APSD-P2*	*APSD-P3*	*APSD-P4*	*APSD-P6*	*APSD-P8*	*APSD-P9*
0-2 ft.	0.02	2.5	2.8	0.11	<0.1	3.5	1.0	0.27	22.0	5.2	17.0	1,335	310	1600	360	3100	2900	2874	5813
1-2 ft.	0.14	----	----	----	↓	↓	↓	↓	↓	↓	↓	----	↓	↓	↓	↓	↓	↓	↓
2-3 ft.	----	----	----	----								----							
2-4 ft.	0.18	0.13	5.5	7.3								620							
3-5 ft.	----	----	----	----								----							
4-6 ft.	0.03	0.04	5.6	4.6								2,225							
6-8 ft.	0.04	0.02	----	2.6	Composite Samples from 0 to 7 feet							305	Composite Samples from 0 to 7 feet						
8-10 ft.	0.33	<0.02	0.52	1.8	----	----	----	----	----	----	----	335	----	----	----	----	----	----	----
9-10 ft.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
10-11 ft.	0.1	<0.02	0.45	0.08	----	----	----	----	----	----	----	342	----	----	----	----	----	----	----
11-12 ft.	----	<0.02	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
12-14 ft.	<0.02	0.09	----	0.07	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
14-16 ft.	----	0.41	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16-18 ft.	----	0.05	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
17-19 ft.	----	----	----	----	----	----	----	----	----	----	----	82	----	----	----	----	----	----	----
Cadmium	EP TOX Cd (mg/L)																		
DEPTH \ *SITE*	*APSD-1*	*APSD-2*	*APSD-3*	*APSD-4*	*APSD-P1*	*APSD-P2*	*APSD-P3*	*APSD-P4*	*APSD-P6*	*APSD-P8*	*APSD-P9*	*DH-29*	*APSD-P1*	*APSD-P2*	*APSD-P3*	*APSD-P4*	*APSD-P6*	*APSD-P8*	*APSD-P9*
0-2 ft.	2	4.8	3.7	2.6	----	----	----	----	----	15.0	8.2	146	<100	420	<100	380	480	844	602
1-2 ft.	0.25	----	----	----	----	----	----	----	----	↓	↓	----	↓	↓	↓	↓	↓	↓	↓
2-3 ft.	----	----	----	----	----	----	----	----	----			----							
2-4 ft.	0.15	0.11	4	1.5	----	----	----	----	----			119							
3-5 ft.	----	----	----	----	----	----	----	----	----			----							
4-6 ft.	0.03	0.07	8.6	0.1	----	----	----	----	----			120							
6-8 ft.	<0.01	0.07	----	<0.01	----	----	----	----	----			58	Composite Samples from 0 to 7 feet						
8-10 ft.	<0.01	0.04	0.8	0.01	----	----	----	----	----	----	----	40	----	----	----	----	----	----	----
9-10 ft.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
10-11 ft.	<0.01	0.05	0.28	<0.01	----	----	----	----	----	----	----	27	----	----	----	----	----	----	----
11-12 ft.	----	0.05	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
12-14 ft.	<0.01	0.12	----	<0.01	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
14-16 ft.	----	0.06	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16-18 ft.	----	0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
17-19 ft.	----	----	----	----	----	----	----	----	----	----	----	27	----	----	----	----	----	----	----
Lead	EP TOX Pb (mg/L)																		
DEPTH \ *SITE*	*APSD-1*	*APSD-2*	*APSD-3*	*APSD-4*	*APSD-P1*	*APSD-P2*	*APSD-P3*	*APSD-P4*	*APSD-P6*	*APSD-P8*	*APSD-P9*	*DH-29*	*APSD-P1*	*APSD-P2*	*APSD-P3*	*APSD-P4*	*APSD-P6*	*APSD-P8*	*APSD-P9*
0-2 ft.	50	3	0.02	2.5	----	----	----	----	----	5.2	0.6	26800	4900	4800	3100	610	11100	7589	1869
1-2 ft.	0.9	----	----	----	----	----	----	----	----	↓	↓	----	↓	↓	↓	↓	↓	↓	↓
2-3 ft.	----	----	----	----	----	----	----	----	----			----							
2-4 ft.	0.66	0.1	<0.02	0.04	----	----	----	----	----			2265							
3-5 ft.	----	----	----		----	----	----	----	----			----							
4-6 ft.	0.1	0.03	<0.02	<0.02	----	----	----	----	----			1038							
6-8 ft.	0.05	0.07	----	<0.02	----	----	----	----	----			6720	Composite Samples from 0 to 7 feet						
8-10 ft.	0.08	0.04	0.03	<0.02	----	----	----	----	----	----	----	5070	----	----	----	----	----	----	----
9-10 ft.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
10-11 ft.	0.03	0.03	0.02	<0.02	----	----	----	----	----	----	----	9523	----	----	----	----	----	----	----
11-12 ft.	----	0.06	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
12-14 ft.	0.02	0.14	----	<0.02	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
14-16 ft.	----	0.33	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16-18 ft.	----	0.07	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
17-19 ft.	----	----	----	----	----	----	----	----	----	----	----	483	----	----	----	----	----	----	----

Notes: EP Toxicity Characteristic Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L
Toxicity Characteristic Leaching Procedure (TCLP) Regulatory Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L



CC/RA REPORT ASARCO EAST HELENA FACILITY

ACID PLANT SEDIMENT DRYING AREA AND UPPER/LOWER LAKE AREA SOIL SAMPLING LOCATIONS

FIGURE 4-1-6

007\0867\065\0165\1/18/99\K:\DATA\PROJECT\0867\ULLOCAT.CDR

ASARCO INCORPORATED
CC/RA REPORT
ASARCO EAST HELENA FACILITY
EAST HELENA, MONTANA

PLANT AREA
SOIL STOCKPILES

FIGURE
4-1-7

UPDATE TIME: 10:19AM
007\ 0867\065\0127\HEL\011899\I:\STORAGE\B6799a17.dwg

Hydrometrics, Inc. Consulting Scientists, Engineers and Contractors

Former Upper Ore Storage Area between Upper Lake and Lower Lake

The area between Upper and Lower Lake formerly contained stockpiles of ore and fluxes, as well as soil piles and construction debris from historical plant site activities. Storage of ore in this area was discontinued in 1989 and remaining ore materials were removed (see Figure 4-1-7).

Soil quality data were collected between Upper and Lower Lake as part of several investigations.

- Eight exploratory test pits (LLB-1 through LLB-8) were excavated and sampled in 1990. Soil samples were collected from the test pits at depths of 1 to 2 feet, 2 to 3 feet, 3 to 5 feet and 9 to 10 feet. These samples were analyzed for total and TCLP metals. The test pits were exploratory in nature and were not conducted as part of the RD/RA program.
- Soil samples were also collected between Upper and Lower Lake in October 1993 during installation of monitoring wells APSD-9 through APSD-12. Soil samples were collected at two-foot intervals to depths of 14 to 16 feet and analyzed for total arsenic and metals.

Sample locations are shown in Figure 4-1-6. The test pit and APSD drilling and analytical results were presented and discussed in the March 1994 Pre-Final (90%) Design Report for Lower Lake and are summarized in Table 4-1-8.

The soils data from APSD 9 through 12 show soil arsenic concentrations ranging from 58 mg/kg to 2,525 mg/kg in the soil pile areas between Upper and Lower Lakes with the highest concentrations present at DH-9 and DH-10 at depths of 8 to 10 feet. Similar or higher concentration ranges were reported at shallow depths in test pits LLB-1 through LLB-8. Cadmium concentrations ranged from 1 to 396 mg/kg in the APDS wells and lead ranges from 366 to 28,651 mg/kg. All eight of the LLB test pit locations had samples failing TCLP for 1 or more parameters (see results in Table 4-1-9).

TABLE 4-1-9: UPPER AND LOWER LAKE AREA SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM & LEAD

APSD SITES											
Arsenic	EP Tox As (mg/L)		Total As (mg/Kg)								
DATE	8/21/91	8/21/91	10/20/93	10/20/93	10/20/93	10/20/93	10/20/93	10/20/93	10/25/93	10/20/93	
DEPTH \ *SITE*	*APSD-5*	*APSD-6*	*APSD-7*	*APSD-8*	*APSD-9*	*APSD-10*	*APSD-11*	*APSD-12*	*APSD-13*	*APSD-14*	
0-2 ft.	0.15	0.34	1256	509	543	1299	850	881	7433	----	
2-4 ft.	0.18	0.07	293	----	851	895	1266	738	7443	3379	
4-6 ft.	0.21	0.03	202	352	1631	891	81	191	7551	15778	
6-8 ft.	0.08	0.14	378	----	1754	1954	217	68	5952	9319	
8-10 ft.	0.12	0.11	----	320	2391	2525	130	----	5167	10686	
10-12 ft.	0.02	0.02	----	326	1461	1242	112	94	5757	----	
10-16 ft.	----	----	443	----	----	----	----	----	----	----	
12-14 ft.	0.03	0.07	----	93	840	1184	59	80	7194	13842	
14-16 ft.	0.03	----	----	68	471	462	----	----	2724	1232	
16-18 ft.	----	----	----	----	----	----	----	----	2324	----	
18-20 ft.	----	----	----	----	----	----	----	----	1233	----	
19-21 ft.	----	----	----	----	----	----	----	----	1760	----	
21-23 ft.	----	----	----	----	----	----	----	----	945	----	
Cadmium	EP Tox Cd (mg/L)		Total Cd (mg/Kg)								
DEPTH \ *SITE*	*APSD-5*	*APSD-6*	*APSD-7*	*APSD-8*	*APSD-9*	*APSD-10*	*APSD-11*	*APSD-12*	*APSD-13*	*APSD-14*	
0-2 ft.	0.36	5.2	336	116	113	125	244	158	111	----	
2-4 ft.	0.12	0.22	152	----	80	230	329	396	107	99	
4-6 ft.	0.37	0.95	50	19	43	187	9	49	130	349	
6-8 ft.	0.13	2.6	46	----	37	288	37	24	127	485	
8-10 ft.	0.22	1.9	----	32	42	220	24	----	102	489	
10-12 ft.	0.17	0.97	----	16	34	110	11	24	81	----	
10-16 ft.	----	----	47	----	----	----	----	----	----	----	
12-14 ft.	0.2	0.13	----	1	23	69	6	7	113	509	
14-16 ft.	0.28	----	----	2	21	33	----	----	101	965	
16-18 ft.	----	----	----	----	----	----	----	----	172	----	
18-20 ft.	----	----	----	----	----	----	----	----	165	----	
19-21 ft.	----	----	----	----	----	----	----	----	176	----	
21-23 ft.	----	----	----	----	----	----	----	----	263	----	
Lead	EP Tox Pb (mg/L)		Total Pb (mg/Kg)								
DEPTH \ *SITE*	*APSD-5*	*APSD-6*	*APSD-7*	*APSD-8*	*APSD-9*	*APSD-10*	*APSD-11*	*APSD-12*	*APSD-13*	*APSD-14*	
0-2 ft.	1.8	45	34521	10071	6875	20507	11895	11315	256	----	
2-4 ft.	0.85	4.9	4433	----	6436	29431	17064	9060	149	197730	
4-6 ft.	1.9	10.6	2921	748	8878	21943	439	1213	197	16794	
6-8 ft.	0.12	26	2150	----	6862	28651	1736	406	90	7103	
8-10 ft.	2.5	13.3	----	1405	7907	24971	961	----	81	12959	
10-12 ft.	0.26	5.1	----	615	7005	7107	430	542	77	----	
10-16 ft.	----	----	1714	----	----	----	----	----	----	----	
12-14 ft.	0.59	0.59	----	223	3613	4097	258	366	197	16430	
14-16 ft.	1	----	----	187	2526	1996	----	----	295	538	
16-18 ft.	----	----	----	----	----	----	----	----	298	----	
18-20 ft.	----	----	----	----	----	----	----	----	8053	----	
19-21 ft.	----	----	----	----	----	----	----	----	47	----	
21-23 ft.	----	----	----	----	----	----	----	----	51	----	

LLB SITES																				
Arsenic	TCLP As (mg/L)								Total As (mg/Kg)							
DATE	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90
DEPTH \ *SITE*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*
0-2 ft.	28	3.5	513	0.97	8.5	1.5	1.2	19	2100	780	27000	2800	<30	1800	1800	13000
2-3 ft.	0.66	0.85	1.2	0.62	0.57	0.48	16	1.2	70	1200	1900	610	2400	8000	3500	2700
3-5 ft.	0.21	0.54	0.27	0.41	----	0.19	----	----	50	440	900	7700	----	3300	----	----
9-10 ft.	2.2	0.37	----	<0.1	----	----	----	----	50	<30	----	1000	----	----	----	----
Cadmium	TCLP Cd (mg/L)								Total Cd (mg/L)							
DEPTH \ *SITE*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*
0-2 ft.	13	0.9	126	35	0.33	6.6	12	43	480	90	5900	950	<10	290	380	3000
2-3 ft.	0.3	3.3	7.7	2	12	8.8	14	14	20	210	380	250	500	830	650	780
3-5 ft.	0.32	3	3.7	12	----	4.7	----	----	10	110	130	4100	----	700	----	----
9-10 ft.	0.35	0.15	----	2	----	----	----	----	20	<10	----	80	----	----	----	----
Lead	TCLP Pb (mg/L)								Total Pb (mg/L)							
DEPTH \ *SITE*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*
0-2 ft.	3.3	0.68	1.2	184	2.2	51	176	51	2400	4600	7700	11000	460	15000	18000	11000
2-3 ft.	2	36	100	161	240	88	11	179	590	6300	16000	12000	37000	45000	6200	24000
3-5 ft.	2.1	12	153	53	----	130	----	----	570	3500	9600	41000	----	15000	----	----
9-10 ft.	4.8	0.62	----	45	----	----	----	----	620	580	----	7900	----	----	----	----

Notes: EP Toxicity Characteristic Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L
Toxicity Characteristic Leaching Procedure (TCLP) Regulatory Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L

~~1.1.3~~4.1.3 Stockpiles

There are four stockpiles areas on the plant site (Figure 4-1-7) consisting of the following:

1. Soil stockpiles between Upper Lake and Lower Lake (estimated 17,000 cubic yards);
2. The Shew Ridge soil stockpile along the western boundary of the lower ore storage yard (volume unknown);
3. The Lower Lake sediment stockpile in the lower ore storage area (27,000 cubic yards); and
4. The lower ore storage area stockpiles (24,000 cubic yards).

Asarco has proposed constructing an on-site containment facility, which would serve as a remedial action measure for a large portion of these soils. A Corrective Action Management Unit (CAMU) Draft Design Report (Hydrometrics, 1997b) describing this proposal has been submitted to EPA for review and comment.

Stockpiles between Upper and Lower Lake

The area between Upper and Lower Lake formerly served as the Upper Ore Storage Area and contained stockpiles of ore and fluxes, as well as soil piles and construction debris from historical plant site activities. Storage of ore in this area was discontinued in 1989 and remaining ore materials were removed. However, piles of soil and construction debris remain.

Soil samples were collected from existing stockpiles in 1994 as part of the preliminary design analysis for the CAMU and analyzed for total arsenic and lead. The sample results are shown on Exhibit 4-1-4. Thirty eight separate samples were collected from soil stockpiles in area between Upper Lake and Lower Lake (see sample results on Exhibit 4-1-4 for Pile#101

through Pile#115). The sampling results indicate arsenic is present in soil stockpiles at concentrations ranging from 228 to 14,290 mg/kg and lead at concentrations ranging from 3,004 to 46,341 mg/kg. Asarco has included removal of all of the soil stockpiles from this area as part of a CAMU proposal (see Section 5).

<THE FOLLOWING DISCUSSION OF SUBSURFACE SOIL QUALITY DATA HAS BEEN MOVED TO SECTION 4-1-4>

~~Soil quality data were collected between Upper and Lower Lake as part of several investigations.~~

- ~~Eight exploratory test pits were excavated and sampled in 1990. Soil samples were collected from the test pits at depths of 1 to 2 feet, 2 to 3 feet and 3 to 5 feet and analyzed for total and TCLP metals. The test pits were exploratory in nature and were not conducted as part of the RD/RA program.~~
- ~~Four boreholes (APSD-1 through 4) were completed in the former acid plant sediment drying area adjacent to Lower Lake and two boreholes (APSD-5 and APSD-6) were drilled in the area between Upper and Lower Lakes in 1991. Soil samples were collected at 2 foot intervals to depths of 14 to 17 feet. The samples were analyzed for EP Toxicity.~~
- ~~Soil samples were also collected between Upper and Lower Lake in October 1993 during installation of monitoring wells APSD-9 through APSD-12. Soil samples~~
- ~~were collected at two-foot intervals to depths of 14 to 16 feet and analyzed for arsenic and metals by XRF.~~

~~Sample locations are shown in Figure 4-1-3. The test pit and APSD drilling and analytical results were presented and discussed in the Pre-Final (90%) Lower Lake Remediation Project~~

~~**FIGURE 4-1-3. SOIL BORING, MONITORING WELL BORING AND TEST PIT LOCATIONS IN THE UPPER.LOWER LAKE AREA (K:\DATA\PROJECT\0867\ULLOCAT.CDR)**~~

~~Report in March 1994 (Hydrometrics, 1994b). The analytical results are in the CC/RA soil data base in Appendix 3-1-2, and soil boring and monitoring well logs are in Appendix 4-4-1.~~

~~The soils data from APSD 9 through 12 show soil arsenic concentrations ranging from 58 mg/kg to 2,525 mg/kg in the soil pile areas between Upper and Lower Lakes with the highest concentrations present at DH-9 and DH-10 at depths of 8 to 10 feet. Similar or higher concentration ranges were reported at shallow depths in test pits LLB-1 through LLB-8. Cadmium concentrations ranged from 1 to 396 mg/kg in the APDS wells and lead ranges from 366 to 28,651 mg/kg. All eight of the LLB test pit locations had samples failing TCLP for 1 or more parameters (see results in Appendix 3-1-2).~~

~~A Supplemental Environmental Investigation (SEP) for the area between Upper and Lower Lakes is in progress and specifies removal of contaminated stockpile soils from this area. A remedial action plan addressing soil removal in this area has not been completed. However, Asarco has included removal of soil stockpiles from this area in the CAMU proposal (see Section 5).~~

Shew Ridge, Lower Lake Sediment and Lower Ore Storage Stockpiles

In 1989, a new concentrate storage and handling building (CSHB) was constructed ~~as part of the ROD requirements~~ to contain ore stockpiles stored outdoors in the ore storage yard. During construction, soils from the building excavation were visually segregated and then later tested by EPTOX. Soils passing EPTOX were placed in the Shew Ridge soil stockpile along the western perimeter of the lower ore storage yard. The remaining soils were placed in a second stockpile in the lower ore storage yard (Figure 4-1-7). The original EPTOX analyses were not located during the file review for this project. Additional sampling is,

therefore, included as an identified data need for establishing the final disposition of soils in the Shew Ridge soil stockpile (see Section 5).

In addition to soils excavated during construction of the CSHB, the lower ore storage area also contains soils excavated as a result of lead SIP and CERCLA remedial activities on site. In 1994, there was a total of about 50 separate piles in the lower ore storage area consisting of a variety of materials including excavated soils, concrete rubble, wood, fines, asphalt~~,~~ and slag ~~and organic matter~~. Material from those stockpiles was sampled and analyzed by XRF for lead and arsenic. Analytical results are in Appendix 3-1-3 ("pile" series samples) and are summarized on Exhibit 4-1-4. Average concentrations of lead and arsenic were 20,900 ppm and 3250 ppm, respectively. Those materials have since been consolidated into one area of the lower ore storage yard next to the Lower Lake sediments (Figure 4-1-7). Asarco has recommended the 24,000 cubic yards of material in stockpiles in this area be placed in the proposed CAMU.

A Lower Lake sediment stockpile is also in the Lower Ore Storage Area. Sampling and dredging of bottom sediments from Lower Lake was one of the remedial actions specified in EPA's 1989 ROD. The dredged sediments were mechanically dewatered and the filter cake from the dewatering operation was transported to an interim covered stockpile in the Lower Ore Storage Area.

Prior analyses of soil cores from Lower Lake indicate that these sediments would likely fail TCLP (see Appendix 3-1-1, "LLB series data"). Accordingly, the ROD required that the dewatered sediments by stored in the concentrate storage and handling building (CSHB) until they could be smelted. During remedial design, it was discovered that the volume of dried sediments would be too great to store in the CSHB. A Short-Term Storage Plan (Hydrometrics 1997d) was prepared and submitted to EPA. Following EPA review of the Short-Term Storage Plan, a temporary cover for the dewatered sediments was implemented. As a result, the sediments currently reside in a short-term storage facility located in the ore

storage area. The sediments are being stored in a protected environment to prevent contamination of the adjacent area from dispersion of the sediments by wind and water. The sediments are located on a concrete pad to prevent contact with adjacent soils. A containment berm around the perimeter of the sediment pile diverts run-on. A geomembrane cover over the sediments prevents wind and water dispersion and eliminates subsequent generation of leachate.

Approximately 31,000 cubic yards of dewatered sediments were transported to the Lower Ore Storage Area. Four thousand cubic yards of these sediments were smelted prior to the stockpile being covered with a geomembrane liner in October 1997. The sediments will remain in this interim storage facility while EPA considers Asarco's request to modify the sediment smelting requirement of the ROD, and instead dispose of these materials in the on-site CAMU.

4.1.4 Slag

The effect of the slag pile on groundwater and surface water was evaluated as part of the 1990 Comprehensive RI/FS. The evaluation was conducted in accordance with procedures presented in the Comprehensive RI/FS Work Plan (Hydrometrics 1987). Based on the results of the evaluation, the RI/FS concluded that the potential for impacts to groundwater and surface water from slag is low and the subsequent ROD did not specify any remedial action for the Slag Pile Operable Unit. Post-RI/FS monitoring at adjacent surface water and groundwater monitoring sites is on-going. A summary of the slag investigation and the findings of the RI relative to slag are presented below.

4.1.4.1 Investigation of Potential Groundwater Impacts

Slag Infiltration Test Basin Construction, Water Level Measurement, Water Quality Sampling and Analysis

Infiltration and percolation of precipitation into the slag pile were directly measured in slag test basins constructed in fumed and unfumed slag. Fumed slag is a by-product of the zinc

5.2 REMEDIAL ACTION MEASURES

Remedial Action measures are shown in Table 5-2-1. In accordance with the Consent Decree (Paragraphs 27 and 28), the interim and final remedial measures implemented at the East Helena site were evaluated for criteria listed in the consent decree. Table 5-2-1 describes remedial measures for each CC/RA area or operable unit, and provides an evaluation of each action based on the following criteria:

- Interim action objectives,
- Design description,
- Construction description,
- O&M requirements,
- Effectiveness of the action,
- Is the action consistent with long-term measures and
- Potential additional measures.

The evaluation addresses actions implemented as part of the CERCLA program for the site, as well as actions implemented as part of other regulatory programs, and voluntary remedial measures implemented as part of plant site operations. The evaluation also addresses the effectiveness of the action including comparison of remedial events and water quality changes shown in Appendix 4-3-1 and in Figures 5-2-1, 5-2-2, 5-2-3, 5-2-4 and 5-2-5. The figures are water quality trend graphs similar to the plots shown in Appendix 4-3-1, but include remedial actions that are discussed in detail in the interim and final remedial action evaluation in Table 5-2-1.

All of the remediation activities and other events that affect the CC/RA areas and operable units are listed in Exhibit 5-1-1. All of the remedial actions listed on Exhibit 5-1-1 are part of the Evaluation of Interim Remedial Action Measures in Table 5-2-1. As Table 5-2-1 shows, most of the activities evaluated have potential for follow-up actions, however, some of the actions implemented are considered final. Near-final actions include construction of the stormwater containment system, and replacement of Wilson Ditch.

TABLE 4-1-9: UPPER AND LOWER LAKE AREA SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM & LEAD

APSD SITES											
Arsenic	EP Tox As (mg/L)		Total As (mg/Kg)								
DATE	8/21/91	8/21/91	10/20/93	10/20/93	10/20/93	10/20/93	10/20/93	10/20/93	10/25/93	10/20/93	
DEPTH \ *SITE*	*APSD-5*	*APSD-6*	*APSD-7*	*APSD-8*	*APSD-9*	*APSD-10*	*APSD-11*	*APSD-12*	*APSD-13*	*APSD-14*	
0-2 ft.	0.15	0.34	1256	509	543	1299	850	881	7433	----	
2-4 ft.	0.18	0.07	293	----	851	895	1266	738	7443	3379	
4-6 ft.	0.21	0.03	202	352	1631	891	81	191	7551	15778	
6-8 ft.	0.08	0.14	378	----	1754	1954	217	68	5952	9319	
8-10 ft.	0.12	0.11	----	320	2391	2525	130	----	5167	10686	
10-12 ft.	0.02	0.02	----	326	1461	1242	112	94	5757	----	
10-16 ft.	----	----	443	----	----	----	----	----	----	----	
12-14 ft.	0.03	0.07	----	93	840	1184	59	80	7194	13842	
14-16 ft.	0.03	----	----	68	471	462	----	----	2724	1232	
16-18 ft.	----	----	----	----	----	----	----	----	2324	----	
18-20 ft.	----	----	----	----	----	----	----	----	1233	----	
19-21 ft.	----	----	----	----	----	----	----	----	1760	----	
21-23 ft.	----	----	----	----	----	----	----	----	945	----	
Cadmium	EP Tox Cd (mg/L)		Total Cd (mg/Kg)								
DEPTH \ *SITE*	*APSD-5*	*APSD-6*	*APSD-7*	*APSD-8*	*APSD-9*	*APSD-10*	*APSD-11*	*APSD-12*	*APSD-13*	*APSD-14*	
0-2 ft.	0.36	5.2	336	116	113	125	244	158	111	----	
2-4 ft.	0.12	0.22	152	----	80	230	329	396	107	99	
4-6 ft.	0.37	0.95	50	19	43	187	9	49	130	349	
6-8 ft.	0.13	2.6	46	----	37	288	37	24	127	485	
8-10 ft.	0.22	1.9	----	32	42	220	24	----	102	489	
10-12 ft.	0.17	0.97	----	16	34	110	11	24	81	----	
10-16 ft.	----	----	47	----	----	----	----	----	----	----	
12-14 ft.	0.2	0.13	----	1	23	69	6	7	113	509	
14-16 ft.	0.28	----	----	2	21	33	----	----	101	965	
16-18 ft.	----	----	----	----	----	----	----	----	172	----	
18-20 ft.	----	----	----	----	----	----	----	----	165	----	
19-21 ft.	----	----	----	----	----	----	----	----	176	----	
21-23 ft.	----	----	----	----	----	----	----	----	263	----	
Lead	EP Tox Pb (mg/L)		Total Pb (mg/Kg)								
DEPTH \ *SITE*	*APSD-5*	*APSD-6*	*APSD-7*	*APSD-8*	*APSD-9*	*APSD-10*	*APSD-11*	*APSD-12*	*APSD-13*	*APSD-14*	
0-2 ft.	1.8	45	34521	10071	6875	20507	11895	11315	256	----	
2-4 ft.	0.85	4.9	4433	----	6436	29431	17064	9060	149	197730	
4-6 ft.	1.9	10.6	2921	748	8878	21943	439	1213	197	16794	
6-8 ft.	0.12	26	2150	----	6862	28651	1736	406	90	7103	
8-10 ft.	2.5	13.3	----	1405	7907	24971	961	----	81	12959	
10-12 ft.	0.26	5.1	----	615	7005	7107	430	542	77	----	
10-16 ft.	----	----	1714	----	----	----	----	----	----	----	
12-14 ft.	0.59	0.59	----	223	3613	4097	258	366	197	16430	
14-16 ft.	1	----	----	187	2526	1996	----	----	295	538	
16-18 ft.	----	----	----	----	----	----	----	----	298	----	
18-20 ft.	----	----	----	----	----	----	----	----	8053	----	
19-21 ft.	----	----	----	----	----	----	----	----	47	----	
21-23 ft.	----	----	----	----	----	----	----	----	51	----	

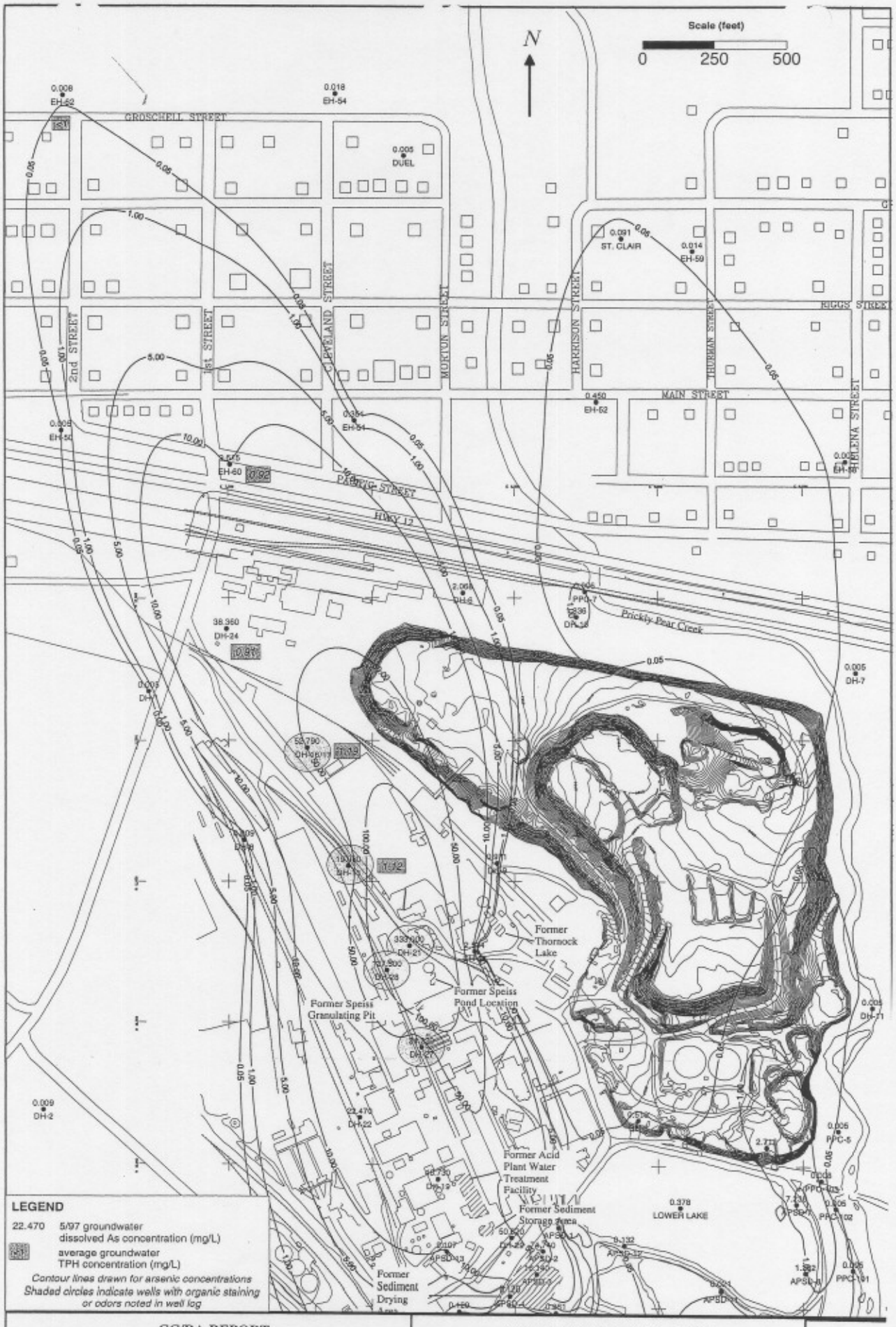
LLB SITES																				
Arsenic	TCLP As (mg/L)								Total As (mg/Kg)							
DATE	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90	11/7/90
DEPTH \ *SITE*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*
0-2 ft.	28	3.5	513	0.97	8.5	1.5	1.2	19	2100	780	27000	2800	<30	1800	1800	13000
2-3 ft.	0.66	0.85	1.2	0.62	0.57	0.48	16	1.2	70	1200	1900	610	2400	8000	3500	2700
3-5 ft.	0.21	0.54	0.27	0.41	----	0.19	----	----	50	440	900	7700	----	3300	----	----
9-10 ft.	2.2	0.37	----	<0.1	----	----	----	----	50	<30	----	1000	----	----	----	----
Cadmium	TCLP Cd (mg/L)								Total Cd (mg/L)							
DEPTH \ *SITE*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*
0-2 ft.	13	0.9	126	35	0.33	6.6	12	43	480	90	5900	950	<10	290	380	3000
2-3 ft.	0.3	3.3	7.7	2	12	8.8	14	14	20	210	380	250	500	830	650	780
3-5 ft.	0.32	3	3.7	12	----	4.7	----	----	10	110	130	4100	----	700	----	----
9-10 ft.	0.35	0.15	----	2	----	----	----	----	20	<10	----	80	----	----	----	----
Lead	TCLP Pb (mg/L)								Total Pb (mg/L)							
DEPTH \ *SITE*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*	*LLB-1*	*LLB-2*	*LLB-3*	*LLB-4*	*LLB-5*	*LLB-6*	*LLB-7*	*LLB-8*
0-2 ft.	3.3	0.68	1.2	184	2.2	51	176	51	2400	4600	7700	11000	460	15000	18000	11000
2-3 ft.	2	36	100	161	240	88	11	179	590	6300	16000	12000	37000	45000	6200	24000
3-5 ft.	2.1	12	153	53	----	130	----	----	570	3500	9600	41000	----	15000	----	----
9-10 ft.	4.8	0.62	----	45	----	----	----	----	620	580	----	7900	----	----	----	----

Notes: EP Toxicity Characteristic Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L
Toxicity Characteristic Leaching Procedure (TCLP) Regulatory Limits: As 5 mg/L, Cd = 1 mg/L, Pb = 5 mg/L

TABLE 4-1-5: FORMER THORNOCK LAKE SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM AND LEAD

Sample Site	Sample Date	Sample Depth[1]	Material	Total Metals (mg/Kg)			EP Tox (mg/L)[2]			SPLP (mg/L)[2][4]		
				As	Cd	Pb	As	Cd	Pb	As	Cd	Pb
TH-1	12/18/87	1-2 ft.	----	34950	16525	17325	----	----	----	----	----	----
	12/18/87	2-3 ft.	----	43900	35000	21075	----	----	----	----	----	----
	12/18/87	3-4 ft.	----	120375	106950	21875	----	----	----	----	----	----
	12/18/87	4-5 ft.	----	52	0.75	6.8	----	----	----	----	----	----
TH-2	12/18/87	0.5-2 ft.	----	691	242	8935	----	----	----	----	----	----
	12/18/87	2-4 ft.	----	44	3.8	221	----	----	----	----	----	----
	12/18/87	6-8 ft.	----	22	3.4	170	----	----	----	----	----	----
	12/18/87	8-10 ft.	----	53	1.9	14	----	----	----	----	----	----
	12/18/87	10-12 ft.	----	191	5.5	64	----	----	----	----	----	----
	12/18/87	15-17 ft.	----	164	3	28	----	----	----	----	----	----
	12/18/87	20-21 ft.	----	52	1.5	24	----	----	----	----	----	----
	12/18/87	25-27 ft.	----	21	1.5	41	----	----	----	----	----	----
TL-3	6/24/91	0-4 inches	Fine-grained sediments	45000	33175	158500	193	133	0.6	----	----	----
	6/24/91	4-12 inches	Fine-grained sediments	43900	23225	95000	58.5	31.3	0.3	----	----	----
	6/24/91	1-2 ft.	Fine-grained sediments	36254	15725	64000	118	58.2	1.6	----	----	----
	6/24/91	2-3 ft.	Fine-grained sediments	455	22	2183	0.2	<0.1	0.3	----	----	----
	6/24/91	3-4 ft.	Alluvium	1458	11	230	9.5	<0.1	<0.1	----	----	----
	6/24/91	4-5 ft.	Alluvium	580	14	353	6	0.1	<0.1	----	----	----
TL-4	6/24/91	0-4 inches	Fine-grained sediments	4375	2378	8875	13	16	0.5	----	----	----
	6/24/91	4-12 inches	Fine-grained sediments	550	270	990	3.2	0.6	<0.1	----	----	----
	6/24/91	1-2 ft.	Fine-grained sediments	940	458	990	1.9	0.2	<0.1	----	----	----
	6/24/91	2-3 ft.	Fine-grained sediments	375	127	61	4.8	0.3	<0.1	----	----	----
	6/24/91	3-4 ft.	Fine-grained sediments	310	105	64	4.7	0.2	<0.1	----	----	----
	6/24/91	4'-4.5'	Alluvium	535	154	66	3.6	0.1	<0.1	----	----	----
TL-001	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	1163	135	328	2.8	0.15	<0.1	1.4	0.01	<.1
TL-002	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	1788	493	5250	2.0	1.9	<0.1	0.63	0.31	<.1
TL-003	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	1053	235	1225	2.0	0.78	<0.1	1.6	0.05	<.1
TL-004	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	853	23	453	2.2	0.02	<0.1	2.0	<.01	<.1
TL-005	12/10/91	+ 1 ft.	Slag/Sludge sample (above grade)	3055	510	14,500	0.93	1.3	0.8	1.2	<.01	<.1
TL-006	12/10/91	0	F. gr. sludge intermixed with slag pieces (to 6" dia.)	750	2.2	98	0.23	<.01	<0.1	0.22	<.01	<.1
TL-007	12/10/91	1-2 ft.	F. gr. sludge intermixed with slag pieces (to 6" dia.)	513	0.91	33	<.1	<.01	<0.1	0.32	<.01	<.1
TL-008	12/10/91	2-3 ft.	Sandy, clayey, silt vermuculte, pyrite present	1400	27	55	2.6	<.01	<0.1	3.8	<.01	<.1
TL-009	12/10/91	3-4 ft.	GW - Sands, gravels and cobbles (to 12" dia)	678	28	130	1.8	<.01	<0.1	2.2	<.01	<.1

Notes: (1) Measured from top of natural sediment - i.e., initial pond bottom elevation.
(2) EPToxicity Limits: As=5 mg/L, Cd = 0.5 mg/L, Pb = 5 mg/L
(3) SPLP - Synthetic Precipitation Leach Procedure



CC/RA REPORT
EAST HELENA FACILITY

Location of Organics-Stained Soils Relative to Groundwater Arsenic Plume

FIGURE
4-4-16

k:/data/project/0867/rpt/sec4_4/orgsoil.srf

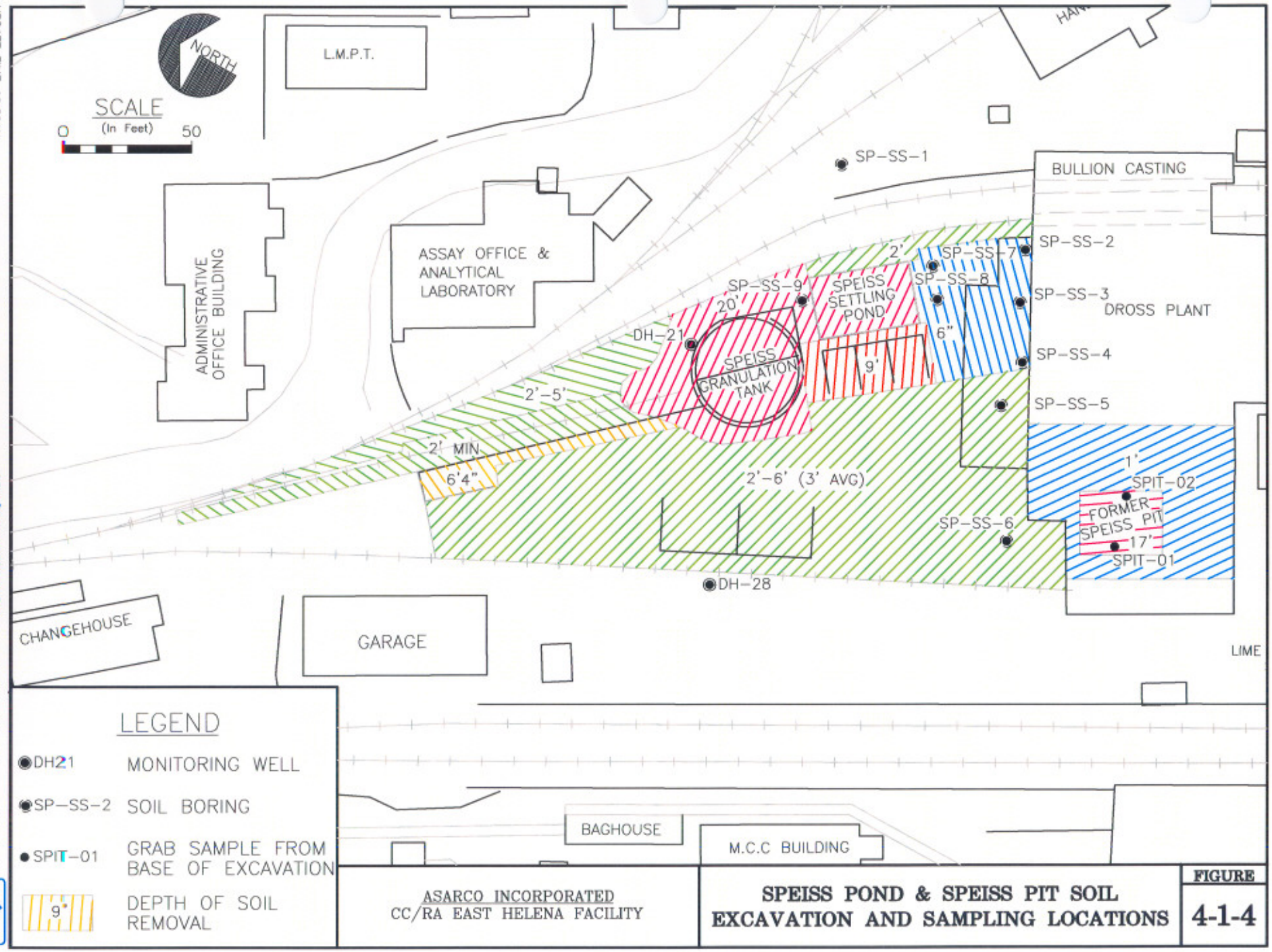
TABLE 4-1-6: SPEISS POND AND SPEISS PIT SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM & LEAD

Arsenic	EP Toxicity As (mg/L)										Total As (mg/Kg)			
DATE	7/25/89	7/25/89	7/25/89	7/26/89	7/26/89	7/28/89	7/28/89	7/28/89	7/28/89	4/23/87	4/23/87	12/11/87	7/24/95	7/24/95
DEPTH \ *SITE*	*SP-SS-1*	*SP-SS-2*	*SP-SS-3*	*SP-SS-4*	*SP-SS-5*	*SP-SS-6*	*SP-SS-7*	*SP-SS-8*	*SP-SS-9*	*DH-21*	*DH-21*	*DH-28*	*SPIT-01*	*SPIT-02*
surface	----	----	----	----	----	----	----	----	----	----	----	----	----	----
0-2 ft.	1.5	0.55	7.5	4.6	1	0.97	<0.2	0.49	0.82	1.5	1750	----	----	----
1-3 ft.	----	----	----	----	----	----	----	----	----		----	749	----	----
2-4 ft.	0.21	0.71	6.4	2.4	<0.2	0.23	0.27	0.2	1	0.91	198	983	----	----
4-6 ft.	<0.2	2.7	4.9	4.2	<0.2	<0.2	<0.2	0.2	<0.2	----	325	79	----	----
6-8 ft.	0.24	0.56	0.39	4.5	<0.2	<0.2	<0.2	0.2	3.4	0.025	36	----	----	----
8-10 ft.	2.3	<0.2	0.93	<0.2	0.69	<0.2	0.23	<0.2	2.9	----	----	----	----	----
10-12 ft.	0.67	0.26	0.28	1.6	0.38	<0.2	<0.2	<0.2	0.45	0.011	34	----	----	----
12-14 ft.	2.3	1.1	0.51	0.57	0.29	<0.2	0.91	<0.2	0.23	----	----	----	----	----
14-16 ft.	3.6	0.31	0.23	1.3	0.26	<0.2	<0.2	<0.2	4.9	----	43	204	----	----
16-18 ft.	<0.2	0.27	<0.2	0.64	0.25	<0.2	<0.2	<0.2	5.8	----	----	----	----	----
18-20 ft.	----	0.96	<0.2	1.7	----	<0.2	0.63	----	2.4	----	----	----	----	----
20-21 ft.	----	----	----	----	----	----	----	----	----	----	375	----	723	1425
24-26 ft.	----	----	----	----	----	----	----	----	----	----	550	285	----	----
30-31 ft.	----	----	----	----	----	----	----	----	----	----	250	545	----	----
36-38 ft.	----	----	----	----	----	----	----	----	----	----	----	32	----	----

Cadmium	EP Toxicity Cd (mg/L)										Total Cd (mg/Kg)			
DEPTH \ *SITE*	*SP-SS-1*	*SP-SS-2*	*SP-SS-3*	*SP-SS-4*	*SP-SS-5*	*SP-SS-6*	*SP-SS-7*	*SP-SS-8*	*SP-SS-9*	*DH-21*	*DH-21*	*DH-28*	*SPIT-01*	*SPIT-02*
surface	----	----	----	----	----	----	----	----	----	----	----	----	----	----
0-2 ft.	0.21	0.1	1.1	0.09	1.6	0.07	1.5	2.5	1.3	0.88	90	----	----	----
1-3 ft.	----	----	----	----	----	----	----	----	----	----	----	306	----	----
2-4 ft.	<0.05	<0.05	0.55	0.35	2.2	0.06	1.9	2	0.22	0.16	5.5	200	----	----
4-6 ft.	<0.05	0.22	0.41	<0.05	0.1	<0.05	<0.05	0.38	<0.05	----	4.5	1.1	----	----
6-8 ft.	<0.05	0.07	<0.05	0.06	0.08	<0.05	<0.05	0.1	<0.05	0.003	6	----	----	----
8-10 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	----	----	----	----	----
10-12 ft.	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.001	<0.5	----	----	----
12-14 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	----	----	----	----	----
14-16 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	----	<0.5	1.2	----	----
16-18 ft.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	----	----	----	----	----
18-20 ft.	----	<0.05	<0.05	<0.05	----	<0.05	<0.05	----	<0.05	----	----	----	----	----
20-21 ft.	----	----	----	----	----	----	----	----	----	----	1.5	----	<10	<10
24-26 ft.	----	----	----	----	----	----	----	----	----	----	1	27	----	----
30-31 ft.	----	----	----	----	----	----	----	----	----	----	4.5	352	----	----
36-38 ft.	----	----	----	----	----	----	----	----	----	----	----	9.8	----	----

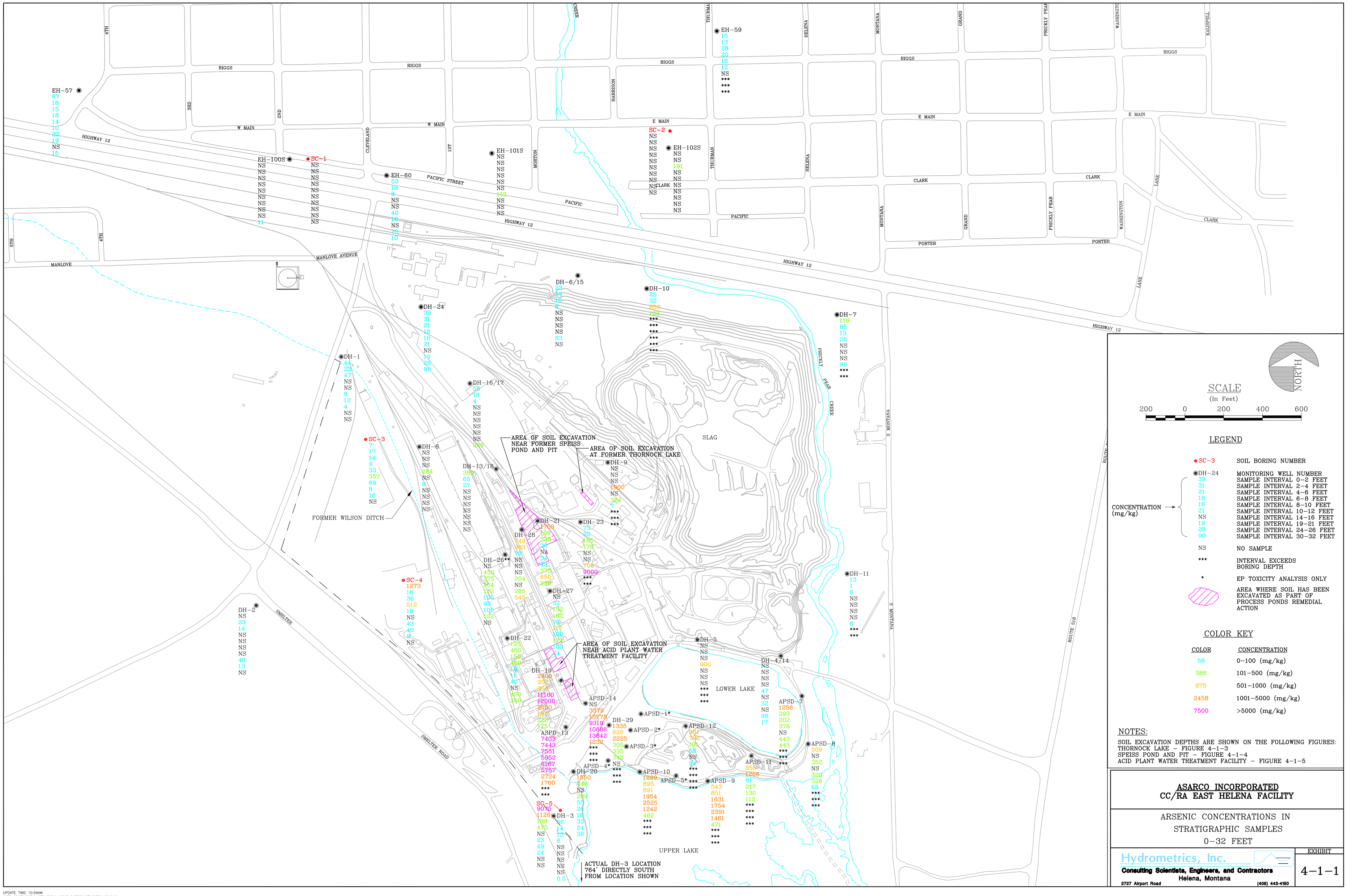
Lead	EP Toxicity Pb (mg/L)										Total Pb (mg/Kg)			
DEPTH \ *SITE*	*SP-SS-1*	*SP-SS-2*	*SP-SS-3*	*SP-SS-4*	*SP-SS-5*	*SP-SS-6*	*SP-SS-7*	*SP-SS-8*	*SP-SS-9*	*DH-21*	*DH-21*	*DH-28*	*SPIT-01*	*SPIT-02*
surface	----	----	----	----	----	----	----	----	----	----	----	----	----	----
0-2 ft.	0.15	0.74	5.4	0.3	25	0.3	18	58	7.1	29	5500	----	----	----
1-3 ft.	----	----	----	----	----	----	----	----	----	----	----	2600	----	----
2-4 ft.	<0.1	0.19	3.1	0.79	16	0.84	17	33	2.1	1.4	170	8535	----	----
4-6 ft.	<0.1	2.1	2.9	<0.1	0.18	<0.1	0.23	3.1	<0.1	----	185	22	----	----
6-8 ft.	<0.1	0.28	0.54	<0.1	0.34	<0.1	<0.1	0.41	<0.1	<0.013	21	----	----	----
8-10 ft.	<0.1	0.12	1.8	<0.1	<0.1	<0.1	<0.1	0.14	<0.1	----	----	----	----	----
10-12 ft.	<0.1	<0.1	0.56	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.013	11	----	----	----
12-14 ft.	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	----	----	----	----	----
14-16 ft.	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	----	12	20	----	----
16-18 ft.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	----	----	----	----	----
18-20 ft.	----	<0.1	<0.1	<0.1	----	<0.1	<0.1	----	<0.1	----	----	----	----	----
20-21 ft.	----	----	----	----	----	----	----	----	----	----	38	----	919	4520
24-26 ft.	----	----	----	----	----	----	----	----	----	----	14	24	----	----
30-31 ft.	----	----	----	----	----	----	----	----	----	----	94	18	----	----
36-38 ft.	----	----	----	----	----	----	----	----	----	----	----	28	----	----

Notes: EPToxicity Limits: As=5 mg/L, Cd = 0.5 mg/L, Pb = 5 mg/L



UPDATE TIME: 10:50AM
007\0867\065\0127\HEL\011899\I:\STORAGE\86799a15.dwg

Hydrometrics, Inc. Consulting Scientists, Engineers and Contractors



UPDATE TIME: 10:59AM
007_0867\D65\0127\HEL\011599\I:\STORAGE\86799A02.DWG

ASARCO INCORPORATED
CC/RA REPORT
ASARCO EAST HELENA FACILITY
EAST HELENA, MONTANA

PLANT AREA
SOIL STOCKPILES

FIGURE
4-1-7

UPDATE TIME: 10:19AM
007\ 0867\065\0127\HEL\011899\I:\STORAGE\B6799a17.dwg

Hydrometrics, Inc. Consulting Scientists, Engineers and Contractors

TABLE 4-1-4: STATISTICAL SUMMARY OF LOWER LAKE SOIL CORE DATA

Interval 1 (Process Sludge)	Total Arsenic (mg/Kg)	Total Cadmium (mg/Kg)	Total Copper (mg/Kg)	Total Lead (mg/Kg)	Total Zinc (mg/Kg)
Geometric Mean	13249	2258	6352	30620	19585
Average	16582	2994	7421	34128	21478
Median	13694	2522	6594	32800	18790
Minimum	2532	452	2131	11891	6877
Maximum	40860	15524	16144	70170	42592
Standard Deviation	10178	3049	4123	15855	9372
Count	21	21	21	21	21
Interval 2 (Top of Marsh to 6 inches)					
Geometric Mean	1879	263	1143	6018	5840
Average	2130	306	1378	7193	6399
Median	1865	254	1091	6146	5759
Minimum	665	54	240	1457	1769
Maximum	6924	758	3753	18017	11248
Standard Deviation	1285	174	870	4240	2665
Count	21	21	21	21	21
Interval 3 (6 to 12 inches)					
Geometric Mean	1040	52	675	2923	3443
Average	1513	215	945	5006	4189
Median	930	109	568	2191	2796
Minimum	188	3	93	541	721
Maximum	10668	2077	4728	37422	11661
Standard Deviation	1812	388	961	6896	2876
Count	41	41	41	41	41
Interval 4 (12 to 18 inches)					
Geometric Mean	784	128	595	2416	3085
Average	1882	624	1146	6485	4228
Median	707	103	495	1852	2906
Minimum	126	15	75	407	590
Maximum	11540	8269	5671	37380	16750
Standard Deviation	3071	1827	1625	11189	3946
Count	20	20	20	20	20
Interval 5 (18 to 36 inches)					
Geometric Mean	260	31	409	1071	2052
Average	1171	106	973	4714	2969
Median	113	13	240	666	1674
Minimum	77	8	91	292	972
Maximum	6917	480	4644	28069	10793
Standard Deviation	2544	177	1641	10323	3507
Count	7	7	7	7	7

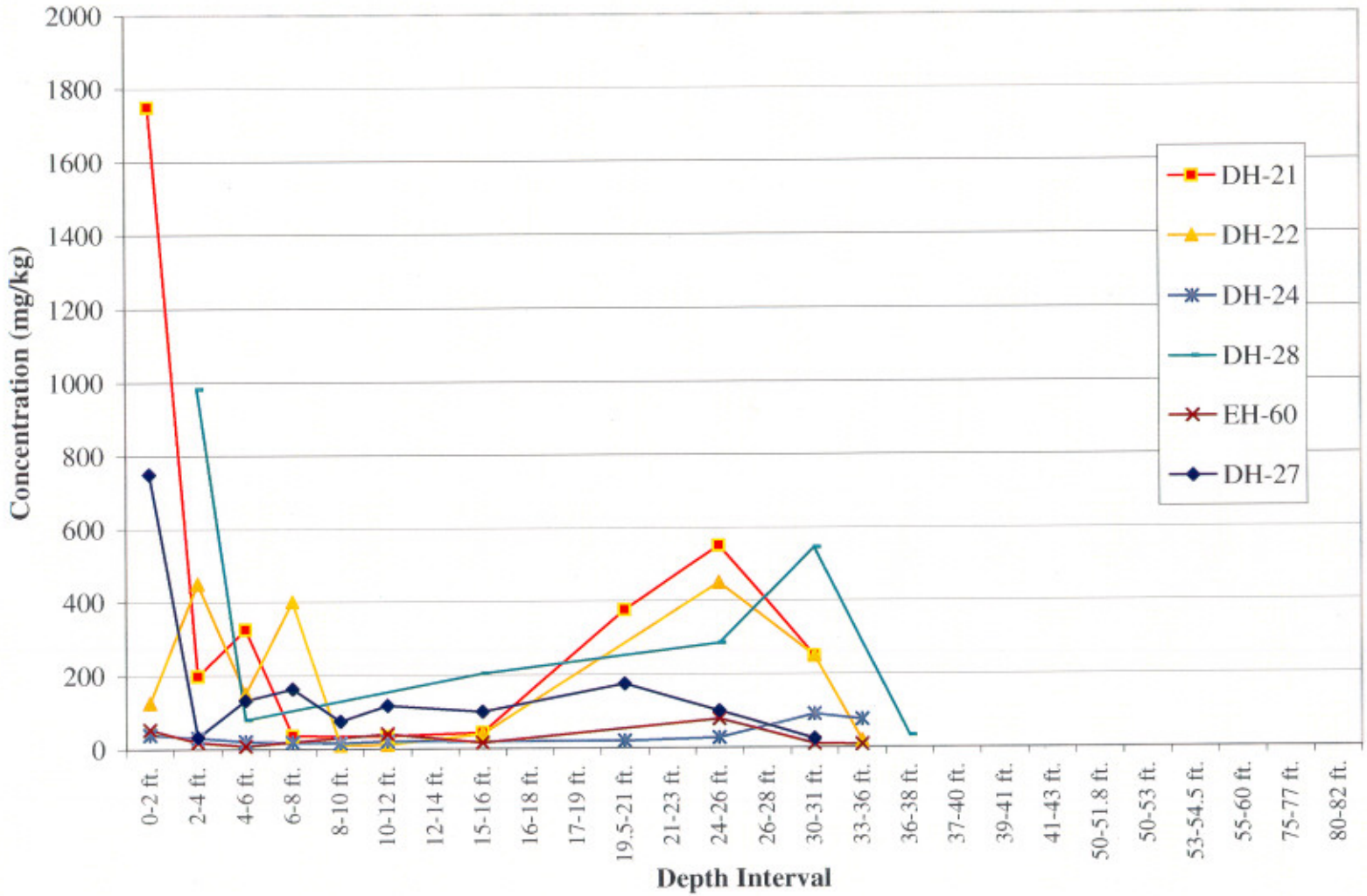
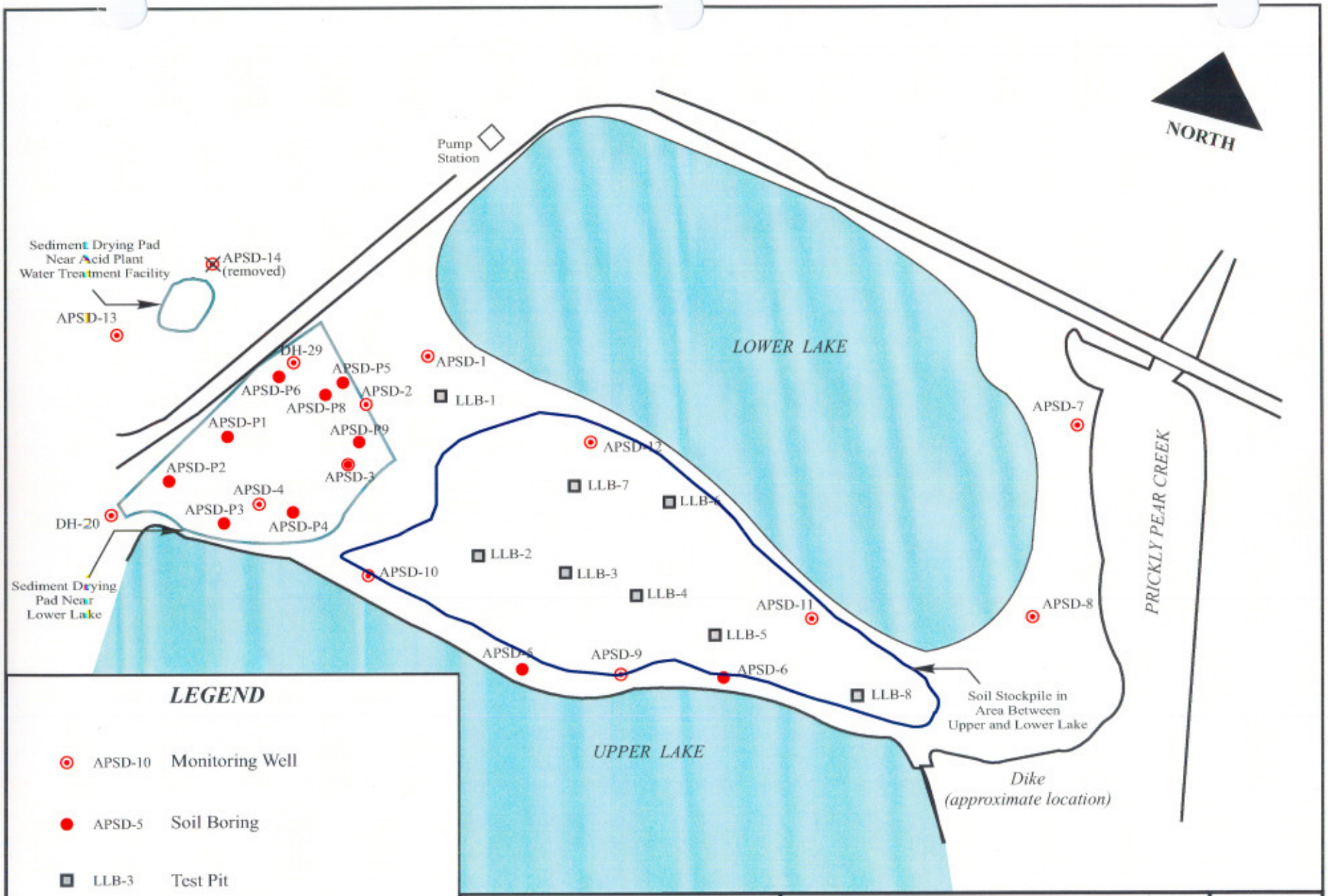


FIGURE 4-1-2. SOIL ARSENIC CONCENTRATIONS VERSUS DEPTH AT SELECTED PLANT SITE MONITORING WELL LOCATIONS



CC/RA REPORT ASARCO EAST HELENA FACILITY

ACID PLANT SEDIMENT DRYING AREA AND UPPER/LOWER LAKE AREA SOIL SAMPLING LOCATIONS

FIGURE 4-1-6

007\0867\065\0165\1/18/99\K:\DATA\PROJECT\0867\ULLOCAT.CDR

TABLE 2-1-2. RFI AND IM SURFACE SOIL SAMPLE COLLECTION AND ANALYSIS MATRIX

Sample Location	Purpose	Sample Types and Depth Intervals	Analytical Parameters[1]	Laboratory Methods	Project Detection Limit Goal
Lower Ore Storage Area (LOS-SS-1 through -16)	Collect additional data to characterize surface soils and near-surface concentration gradients (0-3') within and adjacent to the plant site	Backhoe or Split Spoon 0-4", 4-12", 12-24", 24-36" (four per location)	As Cd Cu Pb Zn	XRF XRF XRF XRF XRF	10 ppm 10 ppm 10 ppm 10 ppm 10 ppm
Upper Ore Storage Area and Between Upper and Lower Lake (UOS-SS-1 through -20)		Backhoe or Split Spoon 0-4", 4-12", 12-24", 24-36" (four per location)	As Cd Cu Pb Zn	SPLP (EPA 1312) SPLP (EPA 1312) SPLP (EPA 1312) SPLP (EPA 1312) SPLP (EPA 1312)	0.1 mg/L 0.1 mg/L 0.1 mg/L 0.1 mg/L 0.1 mg/L
Rail Corridor Areas *Plant Site* (RC-SS-1 through -29) ***NOTE:*** 5 of the 29 rail corridor sample locations were sampled as transects across the corridor consisting of five samples (see RFI Work Plan) *Rail Car Staging Areas* (RCSA 1 through RCSA-8) ***NOTE:*** 4 of 8 rail car staging locations were transects Two transects contained 5 sample sites and two transects contained 6 samples sites		*Plant Site* Backhoe or Split Spoon 0-4", 4-12", 12-24", 24-36" (four per location for 24 sites) (twenty locations at 5 transects) - single hole location samples: -multiple hole transect samples: Split Spoon 0-4", 4-12", 12-24", 24-36" 36-42', 42-60", 60-72", 72-84" or 3 feet below rail subgrade - single hole location samples: -multiple hole transect samples			
Miscellaneous Unpaved Plant Site Areas (UPS-SS-1 through -14)		Backhoe or Split Spoon 0-4", 4-12", 12-24", 24-36" (four per location)			
Unpaved Areas Adjacent to the Plant Site *West and South* (UOS-SS-1 through -11) *North* (UOS-SS-12 through -18) *East* (UOS-SS-19 through -21)		Backhoe or Split Spoon 0-4", 4-12", 12-24", 24-36" (four per location)			

(1) Approximately 5% of the surface soil samples were extracted using the Synthetic Precipitation Leaching Procedure (SPLP; EPA Method 1312), and the extract analyzed for As, Cd, Cu, Pb, and Zn to assess parameter leachability.

TABLE 2-3-1. Summary Statistics for Surface Soils

0"-4" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	173/183	2159	1028	0.01	35500	SS-12	3753	16.5	26	432
COPPER (CU) TOT	175/183	5522	3225	0.01	35750	RC-SA02D-1, 4/24/2001	6917	16.3	69	1127
CADMIUM (CD) TOT	167/183	1225	354	0.05	23400	SS-18	2830	0.24	816	196
LEAD (PB) TOT	177/183	16615	10875	0.01	73866	RC-SS17, 4/18/01	17967	11.6	296	3439
ZINC (ZN) TOT	179/183	13672	7916	0.05	88519	RC-SS25, 4/25/01	17388	46.9	63	2940

4"-12" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	144/155	1133	503	0.10	8753	RC-SS05C-2, 4/6/2001	1518	16.5	17	276
COPPER (CU) TOT	148/155	2624	1319	0.10	16054	RC-SS05C-2, 4/6/2001	3421	16.3	37	604
CADMIUM (CD) TOT	136/155	662	239	0.05	13992	RC-SS06, 4/06/01	1436	0.24	535	128
LEAD (PB) TOT	152/155	12717	7125	0.05	77220	RC-SS07D, 4/09/01	16583	11.6	210	2431
ZINC (ZN) TOT	153/155	9791	6263	0.05	57288	RC-SA06, 4/24/01	11284	46.9	53	2492

1'-2' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	148/154	825	338	0.03	9256	UOS-SS11-3, 10/3/2001	1405	16.5	13	209
COPPER (CU) TOT	148/154	1999	790	0.01	64908	UPS-SS01-3, 3/20/2001	5521	16.3	26	416
CADMIUM (CD) TOT	121/154	415	111	0.02	10110	RC-SS06, 4/06/01	980	0.24	303	73
LEAD (PB) TOT	152/154	8147	3219	0.03	64307	UPS-SS01, 3/20/01	11119	11.6	136	1574
ZINC (ZN) TOT	153/154	6552	4166	0.05	35772	RC-SS20, 4/18/01	7035	46.9	38	1795

2'-3' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	116/128	518	130	0.012	4455	RC-SS06-4, 4/6/2001	906	16.5	6	97
COPPER (CU) TOT	122/128	1130	396	0.004	6741	RC-SS08-4, 4/9/2001	1579	16.3	14	229
CADMIUM (CD) TOT	92/128	397	44	0.003	13588	RC-SS06, 4/06/01	1316	0.24	174	42
LEAD (PB) TOT	123/128	5153	1193	0.003	37460	LOS-SS06, 4/06/01	7888	11.6	60	696
ZINC (ZN) TOT	127/128	6070	1731	0.032	56395	LOS-SS05, 4/05/01	9052	46.9	21	979

3'-5' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	36/39	300	165	10.00	1608	UOS-SS05-5, 4/17/2001	407	16.5	7	115
COPPER (CU) TOT	39/39	671	286	21.00	5763	UOS-SS07-5, 4/17/2001	1051	16.3	15	239
CADMIUM (CD) TOT	28/39	202	51	5.00	1430	RC-SS07C, 4/9/01	349	0.24	203	49
LEAD (PB) TOT	39/39	3547	1885	27.00	15928	UOS-SS05, 4/17/01	4456	11.6	93	1078
ZINC (ZN) TOT	39/39	3159	1000	45.00	12826	LOS-SS10, 4/6/01	3904	46.9	21	980

5'-8' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	30/31	304	49	11.00	2553	RC-SA08A-5, 4/25/2001	592	16.5	4	73
COPPER (CU) TOT	31/31	715	116	17.00	6181	RC-SS27-6, 4/9/2001	1339	16.3	11	185
CADMIUM (CD) TOT	24/31	131	32	5.00	741	RC-SS27, 4/9/01	188	0.24	170	41
LEAD (PB) TOT	31/31	5463	1593	23.00	26889	RC-SS27, 4/9/01	7733	11.6	109	1267
ZINC (ZN) TOT	31/31	4987	1354	46.00	39575	RC-SA06, 4/24/01	8190	46.9	26	1219

8'-11' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	4/4	408	181	16.00	1255	RC-SA08B-8, 4/25/2001	570	16.5	10	160
COPPER (CU) TOT	4/4	779	669	44.00	1734	RC-SA08B-8, 4/25/2001	704	16.3	26	429
CADMIUM (CD) TOT	2/4	68	8	5.00	251	RC-SA08B, 4/25/01	122	0.24	68	16
LEAD (PB) TOT	4/4	1126	182	176.00	3962	RC-SA08B, 4/25/01	1891	11.6	34	390
ZINC (ZN) TOT	4/4	2531	360	138.00	9265	RC-SA08B, 4/25/01	4492	46.9	13	618

TOT = Total

1/2 the [illegible]n limit used for non-detected values.

All ana[illegible]ues are in mg/Kg

TABLE 2-3-2. Summary Statistics for Surface Soils in the Lower Ore Storage Area

0"-4" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	28/28	1893	312	0.03	21625	SS-19	4180	16.5	16	264
COPPER (CU) TOT	27/28	3423	805	0.07	19850	SS-19	5472	16.3	30	488
CADMIUM (CD) TOT	23/28	440	212	0.05	2373	SS-19	647	0.24	339	81
LEAD (PB) TOT	27/28	8377	3003	0.01	28250	LOS-SS11, 03/15/01	9657	11.6	119	1376
ZINC (ZN) TOT	27/28	9257	3188	0.05	46625	SS-5	13183	46.9	29	1377

4"-12" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	24/24	542	85	0.22	2827	LOS-SS11-2, 3/15/2001	798	16.5	7	108
COPPER (CU) TOT	23/24	892	266	0.10	5812	LOS-SS05-2, 4/5/2001	1406	16.3	10	169
CADMIUM (CD) TOT	15/24	309	31	1.80	2825	LOS-SS05, 4/05/01	619	0.24	169	41
LEAD (PB) TOT	24/24	5893	920	0.69	43027	LOS-SS09, 3/15/01	10003	11.6	47	544
ZINC (ZN) TOT	24/24	6021	583	3.70	52306	LOS-SS05, 4/05/01	11424	46.9	15	718

1'-2' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	16/16	502	382	11	1778	LOS-SS06-3	489	16.5	15	246
COPPER (CU) TOT	16/16	876	616	18	2589	LOS-SS06-3	838	16.3	25	408
CADMIUM (CD) TOT	11/16	495	103	5	4686	LOS-SS05, 4/05/01	1145	0.24	307	74
LEAD (PB) TOT	16/16	6294	3657	17	25489	LOS-SS06, 4/06/01	7080	11.6	47	544
ZINC (ZN) TOT	16/16	5233	4458	42	14504	LOS-SS06, 4/06/01	4621	46.9	45	2094

2'-3' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	5/6	462	89	0.10	2820	LOS-SS06-4	870	16.5	4	59
COPPER (CU) TOT	8/9	812	215	0.10	4614	LOS-SS05-4	1272	16.3	7	116
CADMIUM (CD) TOT	12/18	237	14	0.05	2636	LOS-SS05, 4/05/01	621	0.24	78	19
LEAD (PB) TOT	16/18	4860	560	0.05	37460	LOS-SS06, 4/06/01	9330	11.6	25	286
ZINC (ZN) TOT	17/18	5775	1277	0.05	56395	LOS-SS05, 4/05/01	13140	46.9	11	508

3'-5' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	2/2	361	361	291	431	LOS-SS11, 4/06/01	99	16.5	21	354
COPPER (CU) TOT	2/2	725	725	612	838	LOS-SS11, 4/06/01	160	16.3	44	716
CADMIUM (CD) TOT	2/2	284	284	36	532	LOS-SS11, 4/06/01	351	0.24	577	138
LEAD (PB) TOT	2/2	6145	6145	4199	8091	LOS-SS11, 4/06/01	2752	11.6	502	5829
ZINC (ZN) TOT	2/2	6746	6746	666	12826	LOS-SS11, 4/06/01	8598	46.9	62	2923

TOT = Total
1/2 the detection limit used for non-detected values.
All analytical values are in mg/Kg

TABLE 2-3-3. Summary Statistics for Surface Soils in the Upper Ore Storage Area

0"-4" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	28/28	2010	1269	0.01	8091	UOS-SS03-1	2056	16.5	33	548
COPPER (CU) TOT	28/28	4161	3225	0.01	23599	UOS-SS03-1	5309	16.3	54	886
CADMIUM (CD) TOT	28/28	1949	582	0.10	14725	SS-4	3730	0.24	1446	347
LEAD (PB) TOT	28/28	15084	15954	0.02	71196	UOS-SS03-1	14736	11.6	325	3765
ZINC (ZN) TOT	28/28	8885	6578	0.09	44050	SS-4	10444	46.9	55	2600

4"-12" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	25/25	1376	963	34	6958	UOS-SS03-2	1538	16.5	52	864
COPPER (CU) TOT	25/25	2386	1835	76	11639	UOS-SS03-2	2574	16.3	92	1503
CADMIUM (CD) TOT	25/25	590	356	11	4012	UOS-SS03, 4/27/01	917	0.24	1299	312
LEAD (PB) TOT	25/25	13675	11734	150	66080	UOS-SS03, 4/27/01	14344	11.6	683	7928
ZINC (ZN) TOT	25/25	6146	5283	119	16607	UOS-SS03, 4/27/01	4114	46.9	97	4550

1'-2' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	25/25	1556	931	2.00	9256	UOS-SS11-3	1977	16.5	42	700
COPPER (CU) TOT	25/25	2261	1993	0.02	7838	UOS-SS19-3	1879	16.3	60	981
CADMIUM (CD) TOT	24/25	367	251	0.41	1319	UOS-SS08, 4/17/01	380	0.24	678	163
LEAD (PB) TOT	25/25	13265	12839	0.14	40640	UOS-SS08, 4/17/01	10613	11.6	460	5331
ZINC (ZN) TOT	25/25	6609	6439	1.90	22911	UOS-SS4, 4/26/01	5345	46.9	71	3349

2'-3' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	23/31	1118	760	0.01	4337	UOS-SS13-4	1235	16.5	10	161
COPPER (CU) TOT	22/31	2131	1647	0.00	6729	UOS-SS07-4	2134	16.3	17	280
CADMIUM (CD) TOT	22/31	406	227	0.00	1847	UOS-SS03, 4/27/01	561	0.24	252	61
LEAD (PB) TOT	22/31	10521	6353	0.00	33343	UOS-SS13, 10/3/01	10156	11.6	112	1296
ZINC (ZN) TOT	23/31	5777	3577	0.03	16547	UOS-SS4, 4/26/01	5406	46.9	22	1021

3'-5' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	8/8	1005	653	15	3315	UOS-SS6-5	1083	16.5	28	468
COPPER (CU) TOT	8/8	1659	762	22	5763	UOS-SS07-5	2062	16.3	40	656
CADMIUM (CD) TOT	7/8	294	124	5	1367	UOS-SS05, 4/17/01	463	0.24	343	82
LEAD (PB) TOT	8/8	6611	4053	60	15928	UOS-SS05, 4/17/01	6642	11.6	235	2723
ZINC (ZN) TOT	8/8	3227	1995	49	8542	UOS-SS12, 10/03/01	3073	46.9	35	1659

TOT = Total
1/2 the detection limit used for non-detected values.
All analytical values are in mg/Kg

TABLE 2-3-4. Summary Statistics for Surface Soils in Rail Corridor Areas

0"-4" Depth Interval

Parameter	Detection Frequency	Arithmetic Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	76/82	2797	1732	0.01	35500	SS-12	4262	16.5	53	867
COPPER (CU) TOT	40/41	7733	6159	0.09	35750	RC-SA02D-1	7074	16.3	165	2695
CADMIUM (CD) TOT	80/82	1722	651	0.05	23400	SS-18	3475	0.24	1819	437
LEAD (PB) TOT	79/82	26016	20121	0.05	73866	RC-SS17, 4/18/01	19968	11.6	758	8798
ZINC (ZN) TOT	81/82	20472	14762	0.05	88519	RC-SS25, 4/18/01	19234	46.9	165	7755

4"-12" Depth Interval

Parameter	Detection Frequency	Arithmetic Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	75/76	1648	1011	0.10	8753	RC-SS05C-2	1768	16.5	31	507
COPPER (CU) TOT	72/76	3974	2506	0.10	16054	RC-SS05C-2	3991	16.3	76	1246
CADMIUM (CD) TOT	74/76	1071	473	0.05	13992	RC-SS06, 4/6/01	1882	0.24	1342	322
LEAD (PB) TOT	75/76	18435	12293	0.05	77220	RC-SS07D, 4/9/01	19104	11.6	450	5223
ZINC (ZN) TOT	76/76	14045	12284	0.18	57288	RC-SA06, 4/24/01	11960	46.9	128	6021

1'-2' Depth Interval

Parameter	Detection Frequency	Arithmetic Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	71/74	970	418	0.03	8848	RC-SA08B-3	1514	16.5	16	262
COPPER (CU) TOT	35/37	2100	1028	0.01	11818	RC-SS07E-3	2535	16.3	35	567
CADMIUM (CD) TOT	72/74	606	328	0.02	10110	RC-SS06, 4/6/01	1256	0.24	555	133
LEAD (PB) TOT	73/74	9331	5224	0.03	46314	RC-SS07C, 4/9/01	11089	11.6	204	2363
ZINC (ZN) TOT	74/74	9128	9690	0.11	35772	RC-SS20, 4/18/01	7900	46.9	71	3310

2'-3' Depth Interval

Parameter	Detection Frequency	Arithmetic Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	53/55	554	185	0.10	4455	RC-SS06-4	901	16.5	11	176
COPPER (CU) TOT	53/55	1283	691	0.10	6741	RC-SS08-4	1542	16.3	29	469
CADMIUM (CD) TOT	50/55	668	205	0.25	13588	RC-SS06, 4/6/01	1918	0.24	490	118
LEAD (PB) TOT	53/55	5499	2269	0.05	28296	RC-SS06, 4/6/01	7156	11.6	144	1675
ZINC (ZN) TOT	55/55	7907	5283	0.24	37556	RC-SS09C, 4/6/01	8435	46.9	62	2909

3'-5' Depth Interval

Parameter	Detection Frequency	Arithmetic Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	41/42	233	48	10	1525	RC-SA08B-3	349	16.5	5	85
COPPER (CU) TOT	42/42	480	153	21	2765	RC-SS1-5	635	16.3	12	191
CADMIUM (CD) TOT	27/42	214	27	5	3579	RC-SS06, 4/6/01	598	0.24	138	33
LEAD (PB) TOT	42/42	2529	881	27	14120	RC-SA08C, 4/25/01	3272	11.6	73	843
ZINC (ZN) TOT	42/42	2556	654	45	12772	RC-SS14C, 4/10/01	3504	46.9	17	785

5'-8' Depth Interval

Parameter	Detection Frequency	Arithmetic Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	30/30	345	51	11	2553	RC-SA08A-5	621	16.5	5	84
COPPER (CU) TOT	30/30	809	237	17	6181	RC-SS27-6	1358	16.3	14	228
CADMIUM (CD) TOT	23/30	130	32	5	741	RC-SS27, 4/9/01	192	0.24	163	39
LEAD (PB) TOT	30/30	5580	1372	23	26889	RC-SS27, 4/9/01	7837	11.6	108	1248
ZINC (ZN) TOT	30/30	5116	1355	46	39575	RC-SA06, 4/24/01	8298	46.9	26	1223

8'-15' Depth Interval

Parameter	Detection Frequency	Arithmetic Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	4/4	59	22	17	173	RC-SA08B-9	76	16.5	2	35
COPPER (CU) TOT	4/4	180	44	36	594	RC-SA08B-9	276	16.3	5	80
CADMIUM (CD) TOT	2/4	68	8	5	251	RC-SA08B, 4/25/01	122	0.24	68	16
LEAD (PB) TOT	4/4	1126	182	176	3962	RC-SA08B, 4/25/01	1891	11.6	34	390
ZINC (ZN) TOT	4/4	2531	360	138	9265	RC-SA08B, 4/25/01	4492	46.9	13	618

TOT = Total
1/2 the detection limit used for non-detected values.
All analytical values are in mg/Kg

TABLE 2-3-5. Summary Statistics for Surface Soils in the Unpaved On-Plant Site Area

0"-4" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geomean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	19/19	2174	460	0.10	17075		3970	16.5	19	315
COPPER (CU) TOT	19/19	5119	1100	0.10	35350		8806	16.3	44	709
CADMIUM (CD) TOT	18/19	662	433	0.05	3069	UPS-SS01, 3/20/01	954	0.24	1121	269
LEAD (PB) TOT	18/19	9024	8813	0.05	39046	UPS-SS04, 3/16/01	10263	11.6	281	3256
ZINC (ZN) TOT	18/19	12039	6421	0.05	84650	SS-31	21706	46.9	71	3318

4"-12" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	16/18	678	349	0.10	2148		723	16.5	10	160
COPPER (CU) TOT	18/18	1970	754	0.10	9395		2673	16.3	20	326
CADMIUM (CD) TOT	16/18	224	88	0.05	901	UPS-SS01, 3/20/01	267	0.24	263	63
LEAD (PB) TOT	17/18	7345	4625	0.05	24682	UPS-SS06, 3/20/01	7703	11.6	114	1322
ZINC (ZN) TOT	17/18	9619	7874	0.05	41322	UPS-SS14, 3/20/01	11105	46.9	33	1548

1'-2' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	14/15	610	164	0.10	3100		941	16.5	7	119
COPPER (CU) TOT	15/15	5385	206	0.10	64908		16574	16.3	17	274
CADMIUM (CD) TOT	11/15	92	38	0.05	312	UPS-SS13, 3/20/01	102	0.24	117	28
LEAD (PB) TOT	14/15	8304	968	0.05	64307	UPS-SS01, 3/20/01	17002	11.6	73	846
ZINC (ZN) TOT	14/15	4921	1647	0.05	22123	UPS-SS12, 3/16/01	6868	46.9	15	722

2'-4' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	12/13	165	130	10	465		162	16.5	5	84
COPPER (CU) TOT	13/13	778	147	14	3522		1095	16.3	13	218
CADMIUM (CD) TOT	8/13	35	17	5	107	UPS-SS01, 3/20/01	35	0.24	80	19
LEAD (PB) TOT	13/13	2080	932	23	9636	UPS-SS13, 3/20/01	2884	11.6	52	598
ZINC (ZN) TOT	13/13	7881	532	15	41455	UPS-SS13, 3/20/01	13187	46.9	18	852

TOT = Total
1/2 the detection limit used for non-detected values.
All analytical values are in mg/Kg

TABLE 2-3-6. Summary Statistics for Surface Soils in the Unpaved Areas Adjacent to the Plant Site

0"-4" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	25/27	161	101	0.10	746	UOP-SS02-1	181	16.5	3	55
COPPER (CU) TOT	24/27	1516	314	0.10	16375	SS-16	3553	16.3	12	200
CADMIUM (CD) TOT	19/27	78	38	0.05	532	UOP-SS10, 3/8/01	112	0.24	80	19
LEAD (PB) TOT	26/27	2177	1368	0.05	11600	SS-23	2781	11.6	42	485
ZINC (ZN) TOT	26/27	1636	946	0.05	12492	UOP-SS02, 3/29/01	2512	46.9	8	352

4"-12" Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	21/22	98	58	0.10	445	UOP-SS02-2	107	16.5	3	48
COPPER (CU) TOT	21/22	327	126	0.10	1929	UOP-SS02-2	493	16.3	8	125
CADMIUM (CD) TOT	14/22	36	19	0.05	267	UOP-SS02, 3/29/01	57	0.24	59	14
LEAD (PB) TOT	21/22	949	539	0.05	5035	UOP-SS02, 3/29/01	1148	11.6	31	359
ZINC (ZN) TOT	21/22	1698	374	0.05	19398	UOP-SS10, 3/8/01	4312	46.9	7	317

1'-2' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	25/25	95	33	10	548	UOP-SS03-3	145	16.5	3	42
COPPER (CU) TOT	25/25	199	65	18	1908	UOP-SS02-3	404	16.3	5	85
CADMIUM (CD) TOT	9/25	26	5	5	229	UOP-SS02, 3/29/01	48	0.24	46	11
LEAD (PB) TOT	25/25	697	153	29	5540	UOP-SS02, 3/29/01	1205	11.6	19	218
ZINC (ZN) TOT	25/25	699	161	28	7453	UOP-SS02, 3/29/01	1527	46.9	5	221

2'-3' Depth Interval

Parameter	Detection Frequency	Arithmetric Mean	Median	Minimum	Maximum	Location of Maximum	Standard Deviation	Geo. Mean Background	Enrichment Factor	Geometric Mean
ARSENIC (AS) TOT	9/11	41	16	10	388	UOP-SS15-4.1	81	16.5	1	22
COPPER (CU) TOT	11/11	112	42	16	664	UOP-SS15-4.1	171	16.3	3	55
CADMIUM (CD) TOT	1/11	10	5	5	84	UOP-SS15, 3/22/01	17	0.24	26	6
LEAD (PB) TOT	11/11	330	78	23	4088	UOP-SS15, 3/22/01	876	11.6	8	97
ZINC (ZN) TOT	11/11	331	91	11	3479	UOP-SS15, 3/22/01	751	46.9	2	109

TOT = Total
1/2 the detection limit used for non-detected values.
All analytical values are in mg/Kg

TABLE 2-3-7 INTER-PARAMETRIC CORRELATIONS (r) FOR SOIL METALS

Soil Metal Data Log - Transformed					
Variable	**Log Cd**	**Log Pb**	**Log Zn**	**Log As**	**Log Cu**
Log Cd	1				
Log Pb	0.894593	1			
Log Zn	0.88421	0.936927	1		
Log As	0.658261	0.675262	0.655741	1	
Log Cu	0.634274	0.670886	0.677391	0.953843	1

Correlations are significant at $p < 0.05$.

In general, and r value of 0.7 or above (r^2=0.5 or higher) is considered a moderately strong correlation. The r values (or r^2 value) closest to 1 indicate the strongest correlations.